Electronic Supplementary Information for

The *Z*-enoate Assisted, Meyer-Schuster rearrangement Cascade: Unconventional Synthesis of α-arylenone esters

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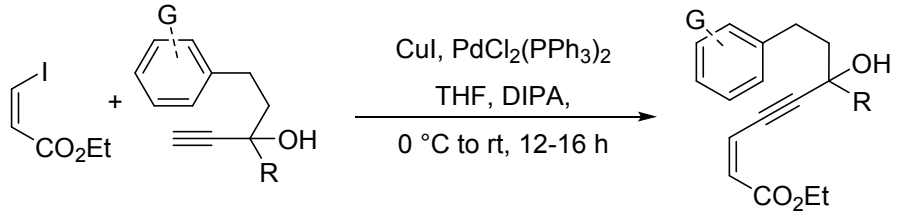
General procedure A: For the synthesis of enynoate-propargylic alcohol precursors (**9a-h** and **12a-m)** for M-S rearrangement *via* Sonogashira cross coupling reaction

The (*Z*)-2-iodo-acrylate[1] (1 equi.) and propargylic alcohol (1.2 equi.) were taken in to a clean, anhydrous round bottom flask equipped with stir bar. Then anhydrous THF and diisopropyl amine (DIPA) were added under nitrogen atmosphere and cooled the flask to 0 °C. Subsequently, CuI (0.15 equi.), and $Pd(PPh_3)_2Cl_2$ (1 mol%) were added to the reaction flask, and stirred the reaction mixture 30 min at 0 °C. The reaction mixture was allowed to warm to room temperature (RT) and continued the stirring for 12-18 h. Reaction progress was monitored by the thin layer chromatography (TLC) analysis. After complete consumption of the iodo-ester, reaction was quenched with saturated NH_4Cl and extracted with ethyl acetate (EtOAc). The combined organic layer was washed with brine, dried ($MgSO_4$) and solvent was removed under reduced pressure. The crude material was typically purified by flash column chromatography using hexane/ethyl acetate mixture as eluent to yield the corresponding (Z)-enynoate-propargylic alcohol derivative (**9a-h** or **12a-m)**.

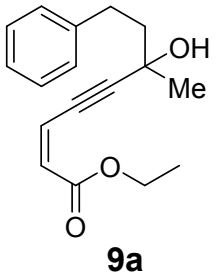
General procedure B: For the acid catalyzed, nucleophilic intercepted Meyer-Schuster rearrangement for the synthesis of bicyclic α-arylenones (**10a-h** or **13a-m)**

To a solution of the enynoate-propargylic alcohol (**7a-k** or **12a-p)** (1equi.) in dichloro-methane (DCM) (5 mL/0.2 mmol, 0.04 *M*) under nitrogen atmosphere was added an acid (0.25 equi.). The reaction tube was stirred either at 0 °C or 55 °C for 1-5 h. After completion of the reaction (by TLC analysis), saturated $NaHCO_3$, and DCM were added to reaction mixture and extracted with DCM. The combined organic layer was washed with the brine, dried ($MgSO_4$) and solvent was evaporated under reduced pressure. The crude material was purified by flash column chromatography using hexane-ethyl acetate mixture as eluent to yield the corresponding bicyclic α-arylenone derivatives (**10a-h** or **13a-m)**.

Sonogashira coupling reaction for the preparation of enoate-propargylic alcohols:



(*Z*)-Ethyl 6-hydroxy-6-methyl-8-phenyloct-2-en-4-ynoate (9a)



9a

The iodo ester[1] (261 mg, 1.16 mmol), alcohol[2] (200 mg, 1.16 mmol), dry THF (12 mL), dry DIPA (2.5 mL), CuI (33 mg, 0.17 mmol) and $PdCl_2(PPh_3)_2$ (8.2 mg, 0.012 mmol) were stirred for 13 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave hydroxy-ester **9a** (290 mg, 1.06 mmol, 92%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.29-7.23 (4 H, m), 7.20-7.15 (1 H, m), 6.17 (1 H, d, *J* = 11.5 Hz), 6.10 (1 H, d, *J* = 11.5 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.97-2.83 (2 H, m), 2.11-1.98 (2 H, m), 1.61 (3 H, s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm.

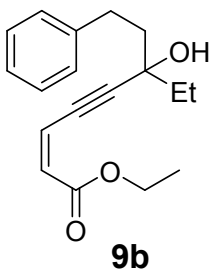
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 142.2, 128.9, 128.6, 128.5, 125.9, 122.8, 105.2, 80.7, 66.6, 60.6, 45.3, 31.2, 29.7 and 14.4 ppm.

IR (neat): 3442 (OH), 3027, 2980, 2932, 2864, 2361, 1710 (C=O), 1608, 1454, 1410, 1188, 1027, 819 and 700 cm^{-1}.

HR ESI-MS:$[C_{17}H_{20}NaO_3]^+$ = $[M+Na]^+$ requires 295.1305; found 295.1312

TLC: R_f = 0.4 (4:1; Hex/EtOAc)

(*Z*)-Ethyl 6-ethyl-6-hydroxy-8-phenyloct-2-en-4-ynoate (9b)



9b

The iodo ester (203 mg, 0.9 mmol), alcohol[3] (140 mg, 0.75 mmol), dry THF (8 mL), dry DIPA (2 ml), CuI (21 mg, 0.11 mmol) and $PdCl_2(PPh_3)_2$ (5.3 mg, 0.008 mmol) were, stirred for 12 h at 0 °C to RT. Purification by

flash column chromatography (4:1 hexane:EtOAc) gave the hydroxy-ester **9b** (170 mg, 0.59 mmol, 79%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31-7.24 (4 H, m), 7.20-7.17 (1 H, m), 6.17 (1 H, d, *J* = 11.5 Hz), 6.11 (1 H, d, *J* = 11.5 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.95-2.85 (2 H, m), 2.06-1.98 (2 H, m), 1.84-1.76 (2 H, m), 1.30 (2 H, t, *J* = 7.05 Hz), 1.31 (3 H, t, *J* = 7.1 Hz) and 1.10 (3 H, t, *J* = 7.5 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 142.3, 129.6, 128.6, 128.5, 126.0, 122.7, 104.3, 81.7, 72.3, 60.6, 43.3, 35.1, 30.9, 14.4 and 8.7 ppm.

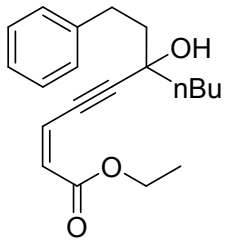
IR (neat): 3446 (OH), 3027, 2973, 2936, 2360, 1710 (C=O), 1608, 1495, 1455, 1409, 1385, 1232, 1029 and 700 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 309.1461; found 309.1467

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-phenethyldec-2-en-4-ynoate (9c)

Iodo ester (202 mg, 0.9 mmol), alcohol **S_1** (175 mg, 0.8 mmol), dry THF (8 mL), dry DIPA (2 ml), CuI (23 mg, 0.12 mmol) and $PdCl_2(PPh_3)_2$ (5.7 mg, 0.008 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave hydroxyl-ester **9c** (210 mg, 0.66 mmol, 82%) as a pale yellow oil.



9c

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31-7.23 (4 H, m), 7.20-7.16 (1 H, m), 6.18 (1 H, d, *J* = 11.5 Hz), 6.11 (1 H, d, *J* = 11.5 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.97-2.84 (2 H, m), 2.54 (1 H, br s), 2.04-1.99 (2 H, m), 1.79-1.73 (2 H, m), 1.58-1.48 (2 H, m), 1.41-1.37 (2 H, m), 1.30 (2 H, t, *J* = 7.1 Hz) and 0.93 (3 H, t, *J* = 7.3 Hz) ppm

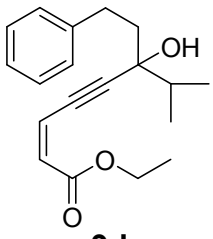
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 142.3, 129.0, 128.6, 128.5, 126.0, 122.6, 104.5, 81.8, 71.9, 60.6, 43.7, 41.9, 30.9, 26.5, 23.0, 14.4 and 14.2 ppm.

IR (neat): 3449 (OH), 3027, 2956, 2935, 2361, 1710 (C=O), 1608, 1496, 1456, 1409, 1384, 1224, 1032 and 700 cm^{-1}.

HR ESI-MS:$[C_{20}H_{26}NaO_3]^+$ = $[M+Na]^+$ requires 337.1774; found 337.1764

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-isopropyl-8-phenyloct-2-en-4-ynoate (9d)



9d

Iodo ester (130 mg, 0.58 mmol), alcohol **S_2** (90 mg, 0.45 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (12.8 mg, 0.07 mmol) and $PdCl_2(PPh_3)_2$ (3.2 mg, 0.005 mmol) were stirred for 12h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxy-ester **9d** (115 mg, 0.38 mmol, 85 %) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.23-7.15 (4 H, m), 7.13-7.08 (1 H, m), 6.12 (1 H, d, *J* = 11.5 Hz), 6.03 (1 H, d, *J* = 11.5 Hz), 4.14 (2 H, q, *J* = 7.1 Hz), 2.88-2.78 (2 H, m), 1.99-1.84 (3 H, m), 1.22 (3 H, t, *J* = 7.1 Hz) and 1.01 (6 H, q, *J* = 6.7 Hz) ppm

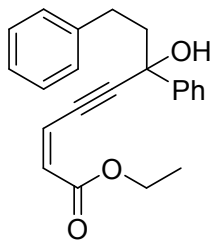
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 142.5, 128.8, 128.7, 128.5, 122.8, 104.1, 82.3, 75.2, 60.6, 41.1, 37.9, 30.8, 18.1, 17.3 and 14.4 ppm.

IR (neat): 3450 (OH), 3026, 2964, 2931, 2361, 1710 (C=O), 1608, 1455, 1409, 1385, 1185, 1030, 818 and 700 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_3]^+$ = $[M+Na]^+$ requires 323.1618; found 323.1624

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6,8-diphenyloct-2-en-4-ynoate (9e)



9e

Iodo ester (123 mg, 0.55 mmol), alcohol**[4]** (100 mg, 0.42 mmol), dry THF (7 mL), dry DIPA (1.3 ml), CuI (12 mg, 0.06 mmol) and $PdCl_2(PPh_3)_2$ (3 mg, 0.004 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxy-ester **9e** (130 mg, 0.39 mmol, 93%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.73-7.71 (2 H, m),7.39-7.36 (2 H, m), 7.32-7.27 (1 H, m), 7.25-7.22 (2 H, m), 7.17-7.13 (3 H, m), 6.24 (1 H, d, *J* = 11.5 Hz), 6.15 (1 H,

d, J = 11.5 Hz), 4.22 (2 H, q, J = 7.2 Hz), 2.91-2.66 (2 H, m), 2.36-2.21 (2 H, m) and 1.28 (3 H, t, J = 7.2 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 144.2, 141.9, 129.5, 128.6, 128.5, 128.4, 128.0, 125.9, 125.7, 122.4, 103.6, 83.1, 73.8, 60.7, 47.1, 31.2 and 14.4 ppm.

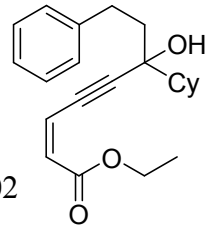
IR (neat): 3421 (OH), 3061, 3027, 2957, 2933, 2361, 1709 (C=O), 1608, 1494, 1450, 1409, 1386, 1299, 1024, 819 and 700cm^{-1}.

HR ESI-MS:$[C_{22}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 357.1461; found 323.162357.14654

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-cyclohexyl-6-hydroxy-8-phenyloct-2-en-4-ynoate (9f)

Iodo ester (89 mg, 0.4 mmol), alcohol **S_3** (80 mg, 0.33 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (9.3 mg, 0.05 mmol) and $PdCl_2(PPh_3)_2$ (2.4 mg, 0.003 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave thevhydroxy-ester **9f** (98 mg, 0.302 mmol, 78%) as a pale yellow oil.



9f

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.28-7.23 (4 H, m), 7.17-7.13 (1 H, m), 6.17 (1 H, d, J = 11.4 Hz), 6.09 (1 H, d, J = 11.4 Hz), 4.21 (2 H, q, J = 7.1 Hz), 2.91 (2 H, t, J = 8.8 Hz), 2.08-1.90 (4 H, m), 1.77-1.75 (2 H, m), 1.67-1.57 (2 H, m) and 1.30-1.16 (8 H, m) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 142.6, 141.9, 128.7, 128.6, 128.4, 122.7, 104.5, 82.4, 74.7, 60.7, 47.6, 30.7, 27.8, 27.1, 26.5, 26.4, 26.3 and 14.4 ppm.

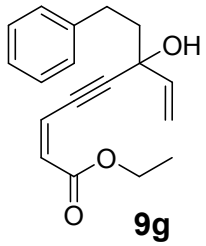
IR (neat): 3450 (OH), 3026, 2929, 2854, 2361, 1710 (C=O), 1607, 1494, 1452, 1409, 13850, 1230, 1186, 1033, 818 and 700 cm^{-1}.

HR ESI-MS:$[C_{22}H_{28}NaO_3]^+$ = $[M+Na]^+$ requires 363.1931; found 363.1937

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-phenethylocta-2,7-dien-4-ynoate (9g)

Iodo ester (172 mg, 0.76 mmol), alcohol **S_4** (110 mg, 0.6 mmol), dry THF (7 mL), dry DIPA (2 ml), CuI (17 mg, 0.09 mmol) and $PdCl_2(PPh_3)_2$ (4 mg, 0.006 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxy-ester **9g** (120 mg, 0.42 mmol, 72%) as a pale yellow oil.



9g

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.30-7.15 (5 H, m), 6.19 (1 H, d, *J* = 11.6 Hz), 6.13 (1 H, d, *J* = 11.6 Hz), 5.99 (1H, dd, *J* = 17.3 & 10.3 Hz), 5.68 (1 H, dd, *J* = 17.1 & 1.3 Hz), 5.25 (1 H, dd, *J* = 10.3 & 1.3 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.93-2.77 (2 H, m), 2.17-2.02 (2 H, m), 1.81 (1 H, br s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 142.0, 140.5, 129.4, 128.6, 128.5, 126.0, 122.4, 115.6, 102.1, 83.0, 72.2, 60.7, 44.0, 30.8 and 14.4 ppm.

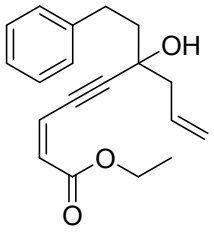
IR (neat): 3435 (OH), 3085, 3062, 3026, 2982, 2955, 2866, 1709 (C=O), 1609, 1566, 1495, 1453, 1385, 1300, 1231, 1188, 1031, 988 and 701 cm^{-1}.

HR ESI-MS:$[C_{18}H_{20}NaO_3]^+$ = $[M+Na]^+$ requires 307.1305; found 307.1311

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-phenethylnona-2,8-dien-4-ynoate (9h)

Iodo ester (204 mg, 0.91 mmol), alcohol **S_5** (140 mg, 0.7 mmol), dry THF (7 mL), dry DIPA (2 ml), CuI (20 mg, 0.11 mmol) and $PdCl_2(PPh_3)_2$ (5 mg, 0.007 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **9h** (170 mg, 0.57 mmol, 82%) as a pale yellow oil.



9h

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.30-7.22 (4 H, m), 7.2--7.16 (1 H, m) 6.18 (1 H, d, *J* = 11.4 Hz), 6.12 (1 H, d, *J* = 11.4 Hz), 6.08-6.00 (1 H, m), 5.25-5.19 (2 H, m), 4.23 (2 H, q, *J* = 7.1 Hz), 2.95-2.91 (2 H, m), 2.65-2.61 (1 H, m), 2.50-2.45 (1H, m), 2.05-2.01 (2 H, t, *J* = 8.3 Hz) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm.

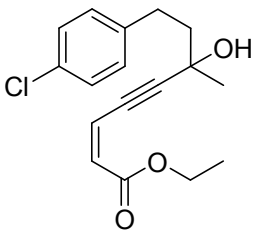
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7 (O-C=O), 142.2, 133.1, 129.2, 128.7, 128.5, 126.0, 122.5, 119.9, 103.7, 81.9, 70.6, 60.6, 46.9, 43.4, 30.8 and 14.4 ppm.

IR (neat): 3405 (OH), 3026, 2957, 2933, 2361, 1708 (C=O), 1609, 1495, 1453, 1385, 1231, 1188, 1031, 820 and 701 cm^{-1}.

HR ESI-MS:$[C_{19}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 321.1461; found 321.1461

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 8-(4-chlorophenyl)-6-hydroxy-6-methyloct-2-en-4-ynoate (12a)



12a

Iodo ester (223 mg, 0.99 mmol), alcohol **S_6** (170 mg, 0.83 mmol), dry THF (8 mL), dry DIPA (2 ml), CuI (23.5 mg, 0.12 mmol) and $PdCl_2(PPh_3)_2$ (5.8 mg, 0.008 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12a** (225 mg, 0.74 mmol, 89%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.25-7.22 (2 H, m), 7.18-7.16 (2 H, m), 6.16 (1 H, d, *J* = 11.5 Hz), 6.12 (1 H, d, *J* = 11.5 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.94-2.83 (2 H, m), 2.07-1.95 (2 H, m), 1.71 (1H, br s), 1.60 (3 H, s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm

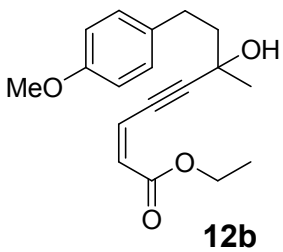
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 140.6, 131.7, 130.0, 129.2, 128.6, 122.6, 104.8, 80.9, 68.6, 60.6 (C-OH), 45.2, 30.6, 30.0 and 14.4 ppm.

IR (neat): 3439 (OH), 2981, 2935, 2864, 2361, 1712 (C=O), 1610, 1491, 1410, 1386, 1188, 1091, 1020, 816 and 665 cm^{-1}.

HR ESI-MS:$[C_{17}H_{19}NaO_3]^+$ = $[M+Na]^+$ requires 329.0915; found 329.0909

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-8-(4-methoxyphenyl)-6-methyloct-2-en-4-ynoate (12b)



12b

Iodo ester (147 mg, 0.65 mmol), alcohol **S_7** (110 mg, 0.54 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (15.4 mg, 0.08 mmol) and

$Pd(PPh_3)_2Cl_2$ (4 mg, 0.006 mmol) were stirred for 14 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12b** (145 mg, 0.48 mmol, 74%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15 (2 H, d, *J* = 8.8 Hz), 6.82 (2 H, d, *J* = 8.8 Hz), 6.17(1 H, d, *J* = 11.5 Hz), 6.10 (1 H, d, *J* = 11.5 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 3.78 (3 H, s), 2.94-2.77 (2 H, m), 2.08-1.97 (2 H, m), 1.60 (3 H, s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 157.9, 134.2, 129.5, 128.8, 122.9, 114.0, 105.4, 80.5, 68.6, 60.6, 55.4, 45.3, 30.3, 29.7 and 14.4 ppm.

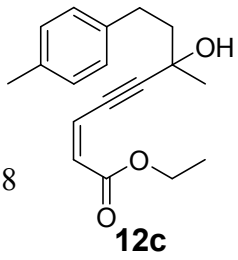
IR (neat): 3443 (OH), 2981, 2950, 2937, 2908, 1709 (C=O), 1611, 1511, 1460, 1299, 1245, 1182, 1085, 1033 and 821 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 325.1410; found 325.1416

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-8-p-tolyloct-2-en-4-ynoate (12c)

Iodo ester (94 mg, 0.41 mmol), alcohol **S_8** (65 mg, 0.34 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (10 mg, 0.05 mmol) and $PdCl_2(PPh_3)_2$ (3 mg, 0.004 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12c** (80 mg, 0.28 mmol, 83%) as a pale yellow oil.



12c

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15-7.09 (4 H, m), 6.18(1 H, d, *J* = 11.5 Hz), 6.11 (1 H, d, *J* = 11.5 Hz), 4.27 (2 H, q, *J* = 7.1 Hz), 3.17 (1 H, br s), 2.94-2.80 (2 H, m), 2.32 (3 H, s), 2.10-1.97 (2 H, m), 1.61 (3 H, s) and 1.31 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 139.0, 135.3, 129.2, 128.8, 128.5, 122.9, 105.4, 80.6, 68.6, 60.6, 45.5, 30.8, 29.7, 21.1 and 14.4 ppm.

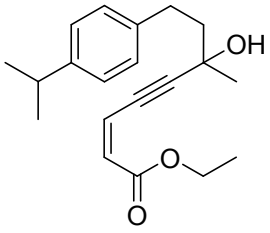
IR (neat): 3442 (OH), 2980, 2934, 2866, 1710 (C=O), 1611, 1515, 1453, 1412, 1186, 1088, 1025 and 810 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 309.1461; found 309.1461

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-8-(4-isopropylphenyl)-6-methyloct-2-en-4-ynoate (12d)

Iodo ester (270 mg, 1.2 mmol), alcohol **S_9** (200 mg, 0.93 mmol), dry THF (8 mL), dry DIPA (2.5 ml), CuI (27 mg, 0.14 mmol) and $PdCl_2(PPh_3)_2$ (7 mg, 0.01 mmol) were stirred for 14 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester 1**2d** (240 mg, 0.76 mmol, 82%) as a pale yellow oil.



12d

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.19-7.13 (4 H, m), 6.18(1 H, d, *J* = 11.5 Hz), 6.11 (1 H, d, *J* = 11.5 Hz), 4.23 (2 H, q, *J* = 7.1 Hz), 2.94-2.80 (3 H, m), 2.10-1.98 (2 H, m), 1.61 (3 H, s) 1.31 (3 H, t, *J* = 7.1 Hz) and 1.24 (6 H, d, *J* = 6.9 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 146.5, 139.4, 128.8, 128.5, 126.6, 122.9, 105.3, 80.6, 68.6, 60.6, 45.3, 33.8, 30.7, 29.7, 24.2 and 14.4 ppm.

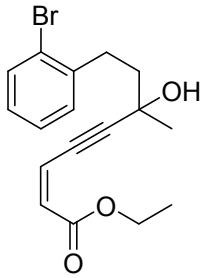
IR (neat): 3443 (OH), 2959, 2930, 2869, 1710 (C=O), 1610, 1513, 1461, 1412, 1366, 1287, 1184, 1089, 1022, 931 and 820 cm^{-1}.

HR ESI-MS:$[C_{20}H_{26}NaO_3]^+$ = $[M+Na]^+$ requires 337.1774; found 337.1779

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 8-(2-bromophenyl)-6-hydroxy-6-methyloct-2-en-4-ynoate (12e)

Iodo ester (139 mg, 0.62 mmol), alcohol **S_{10}** (130 mg, 0.52 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (15 mg, 0.08 mmol) and $PdCl_2(PPh_3)_2$ (4 mg, 0.006 mmol) were stirred for 14 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12e** (152 mg, 0.43 mmol, 83%) as a pale yellow oil.



12e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.51 (1 H, dd, *J* = 8.0 & 1.1 Hz), 7.29 (1 H, dd, *J* = 8.0 & 1.1 Hz), 7.20 (1 H, dt, *J* = 7.5 & 6.0 Hz), 6.17 (1 H, d, *J* = 11.5 Hz), 6.09 (1 H, d, *J*

= 11.5 Hz), 4.21 (2 H, q, *J* = 7.1 Hz), 3.58 (1 H, br s), 3.05-3.01 (2 H, m), 2.10-1.98 (2 H, m), 1.63 (3 H, s) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm

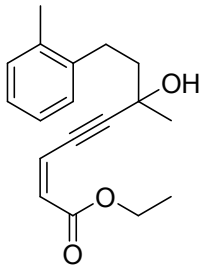
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 141.4, 132.8, 130.6, 128.7, 127.7, 127.6, 124.5, 122.9, 105.3, 80.5, 68.4, 60.6, 43.5, 31.7, 29.4 and 14.3 ppm.

IR (neat): 3439 (OH), 2980, 2934, 2870, 1709 (C=O), 1610, 1470, 1443, 1410, 1368, 1287, 1089, 1024, 819 and 751 cm^{-1}.

HR ESI-MS:$[C_{17}H_{19}BrNaO_3]^+$ = $[M+Na]^+$ requires 373.0410; found 373.0419

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-8-*o*-tolyloct-2-en-4-ynoate (12f)



12f

Iodo ester (292 mg, 1.3 mmol), alcohol **S_{11}** (188 mg, 1 mmol), dry THF (8 mL), dry DIPA (2 ml), CuI (28.5 mg, 0.15 mmol) and $PdCl_2(PPh_3)_2$ (7 mg, 0.01 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12f** (220 mg, 0.77 mmol, 77%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.20-7.08 (4 H, m), 6.19 (1 H, d, *J* = 11.3 Hz), 6.12 (1 H, d, *J* = 11.3 Hz), 4.22 (2 H, q, *J* = 7.1 Hz), 2.96-2.82 (2 H, m), 2.34 (3 H, s), 2.05-1.91 (2 H, m), 1.63 (3H, s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 140.3, 136.2, 130.3, 129.1, 128.9, 128.8, 126.1, 122.9, 105.4, 80.5, 68.6, 60.7, 43.9, 29.6, 28.6, 19.3 and 14.4 ppm.

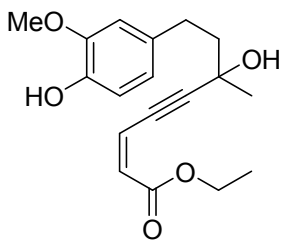
IR (neat): 3442 (OH), 2980, 2931, 2878, 1710 (C=O), 1610, 1492, 1460, 1410, 1385, 1291, 1189, 1025, 930, 821 and 742 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 309.1461; found 309.1461

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-8-(4-hydroxy-3-methoxyphenyl)-6-methyloct-2-en-4-ynoate (12g)

Iodo ester (104 mg, 0.46 mmol), alcohol **S_{12}** (85 mg, 0.4 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (11 mg, 0.06 mmol) and $PdCl_2(PPh_3)_2$ (3 mg, 0.004 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12g** (65 mg, 0.21 mmol, 54%) as a pale yellow oil.



12g

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.81 (1 H, d, *J* = 8.8 Hz), 6.76-6.71(2 H, m), 6.17 (1 H, d, *J* = 11.5 Hz), 6.10 (1 H, d, *J* = 11.5 Hz), 4.21 (2 H, q, *J* = 7.1 Hz), 3.86 (3 H, s), 2.89-2.81 (2 H, m), 2.03-1.96 (3 H, m), 1.59 (3 H, s) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 146.6, 143.8, 134.0, 128.8, 122.9, 121.1, 114.1, 111.3, 105.3, 80.6, 68.8, 60.6, 56.1, 45.6, 30.9, 29.8 and 14.4 ppm.

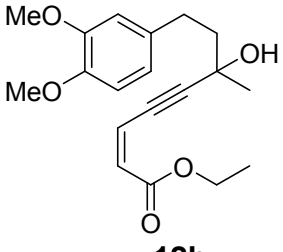
IR (neat): 3427(OH), 2925, 2854, 2364, 2341, 1720 (C=O), 1604, 1515, 1459, 1369, 1266, 1120, 1091, 1028 and 800 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_5]^+ = [M+Na]^+$ requires 341.1359; found 341.1351

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 8-(3,4-dimethoxyphenyl)-6-hydroxy-6-methyloct-2-en-4-ynoate (12h)

Iodo ester (375 mg, 1.7 mmol), alcohol[5] (300 mg, 1.3 mmol), dry THF (10 mL), dry DIPA (3 ml), CuI (37 mg, 0.2 mmol) and $PdCl_2(PPh_3)_2$ (9 mg, 0.013 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12h** (400 mg, 1.2 mmol, 93%) as a pale yellow oil



12h

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.78 (1 H, s), 6.77 (2 H, s), 6.17 (1 H, d, *J* = 11.5 Hz), 6.10 (1 H, d, *J* = 11.5 Hz), 4.21 (2 H, q, *J* = 7.1 Hz), 3.86 (3 H, s), 3.84 (3 H, s), 3.26 (1 H, br s), 2.92-2.27 (2 H, m), 2.05-1.99 (2 H, m), 1.59 (3 H, s) and 1.27 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 148.9, 147.2, 134.7, 128.8, 122.9, 120.3, 111.9, 111.3, 105.3, 80.5, 68.5, 60.6, 56.1, 55.9, 45.5, 30.8, 29.8 and 14.4 ppm.

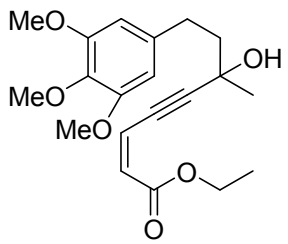
IR (neat): 3426 (OH), 2927, 2856, 2368, 2339, 1714 (C=O), 1600, 1515, 1479, 1368, 1268, 1130, 1091, 1028, 938 and 800 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_5]^+ = [M+Na]^+$ requires 355.1516; found 355.1516

TLC: $R_f = 0.4$ (3:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-8-(3,4,5-trimethoxyphenyl)oct-2-en-4-ynoate (12i)

Iodo ester (77 mg, 0.4 mmol), alcohol[5] (75 mg, 0.3 mmol), dry THF (5 mL), dry DIPA (1 ml), CuI (8 mg, 0.04 mmol) and $PdCl_2(PPh_3)_2$ (2 mg, 0.003 mmol) were stirred for 14 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12i** (68 mg, 0.19 mmol, 68%) as a pale yellow oil.



12i

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.47 (2 H, s), 6.17 (1 H, d, *J* = 11.5 Hz), 6.10 (1 H, d, *J* = 11.5 Hz), 4.20 (2 H, q, *J* = 7.1 Hz), 3.85 (6 H, s), 3.83 (3 H, s), 2.88-2.81 (2 H, m), 2.07-1.97 (2 H, m), 1.61 (3 H, s) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.7, 153.3, 137.9, 128.9, 122.8, 105.6, 105.5, 80.7, 68.6, 60.9, 60.5, 56.2, 45.3, 31.6, 29.8 and 14.4 ppm.

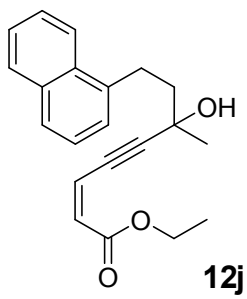
IR (neat): 3438 (OH), 2979, 2934, 2361, 1717 (C=O), 1590, 1510, 1458, 1420, 1239, 1184, 1126, 1010 and 821 cm^{-1}.

HR ESI-MS:$[C_{20}H_{26}NaO_6]^+ = [M+Na]^+$ requires 385.1622; found 385.1631

TLC: $R_f = 0.4$ (3:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-8-(naphthalen-1-yl)oct-2-en-4-ynoate (12j)

Iodo ester (209 mg, 0.9 mmol), alcohol **S_{13}** (160 mg, 0.7 mmol), dry THF (8 mL), dry DIPA (1.8 ml), CuI (20 mg, 0.11 mmol) and $PdCl_2(PPh_3)_2$ (5 mg, 0.007 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc)



12j

gave hydroxyl-ester **12j** (228 mg, 0.56 mmol, 79%) as a pale yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.19 (1 H, d, *J* = 7.9 Hz), 7.86 (1 H, d, *J* = 7.4 Hz), 7.73-7.71 (1 H, m), 7.52-7.46 (2 H, m), 7.42-7.38 (2 H, m), 6.24 (1 H, d, *J* = 11.4 Hz),6.15 (1 H, d, *J* = 11.4 Hz), 4.23 (2 H, q, *J* = 7.1 Hz), 3.47-3.35 (2 H, m), 2.25-2.14 (2 H, m), 1.69 (3 H, s) and 1.30 (3 H, t , *J* = 7.1 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 164.8, 138.3, 134.0, 132.0, 128.8, 126.7, 126.1, 125.9, 125.7, 125.6, 124.1, 122.9, 105.4, 80.7, 68.7, 60.7, 44.5, 29.8, 28.4 and 14.3 ppm.

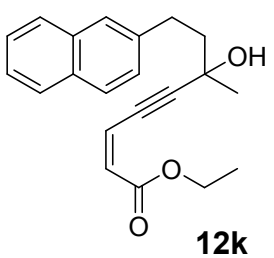
IR (neat): 3437 (OH), 3051, 2980, 1714 (C=O), 1608, 1456, 1402, 1292, 1189, 1099, 1023, 939 and 786 cm^{-1}.

HR ESI-MS:$[C_{21}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 345.1461; found 345.1469

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-8-(naphthalen-2-yl)oct-2-en-4-ynoate (12k)

Iodo ester (200 mg, 0.89 mmol), alcohol **S_{14}** (160 mg, 0.71 mmol), dry THF (8 mL), dry DIPA (1.8 ml), CuI (20 mg, 0.11 mmol) and $PdCl_2(PPh_3)_2$ (5 mg, 0.007 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12k** (228 mg, 0.56 mmol, 79%) as a pale yellow oil.



12k

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.83-7.77 (3 H, m), 7.72 (1 H, s), 7.48-7.40 (3 H, m), 6.20 (1 H, d, *J* = 11.5 Hz), 6.13 (1 H, d, *J* = 11.5 Hz), 4.25 (2 H, q, *J* = 7.1 Hz), 3.78 (1 H, br s), 3.19-3.04 (2 H, m), 2.25-2.16 (2H, m), 1.68 (3 H, s) and 1.32 (3 H, t , *J* = 7.1 Hz) ppm.

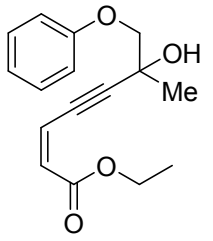
^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.9, 139.7, 133.7, 132.0, 128.6, 127.9, 127.7, 127.5, 127.4, 126.5, 126.0, 125.2, 123.1, 105.5, 80.5, 68.5, 60.7, 45.2, 31.3, 29.7 and 14.3 ppm.

IR (neat): 3439 (OH), 3059, 2982, 1712 (C=O), 1608, 1457, 1405, 1298, 1179, 1093, 1023, 939 and 786 cm^{-1}.

HR ESI-MS:$[C_{21}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 345.1461; found 345.1459

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-7-phenoxyhept-2-en-4-ynoate (12l)



12l

Iodo ester (117 mg, 0.52 mmol), alcohol **S_{15}** (70 mg, 0.4 mmol), dry THF (6 mL), dry DIPA (1 ml), CuI (12 mg, 0.06 mmol) and $PdCl_2(PPh_3)_2$ (3 mg, 0.004 mmol) were stirred for 13 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **12l** (85 mg, 0.32 mmol, 77%) as a pale yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.31-7.27 (2 H, m), 6.99-6.95 (3 H, m), 6.56 (1 H, d, *J* = 11.6 Hz), 6.11 (1 H, d, *J* = 11.6 Hz), 4.21 (2 H, q, *J* = 7.1 Hz), 4.10 (1 H, d, *J* = 8.9 Hz), 4.01 (1 H, d, *J* = 8.9 Hz), 1.91 (1 H, br s), 1.67 (3 H, s) and 1.31 (3 H, t, *J* = 7.1 Hz) ppm.

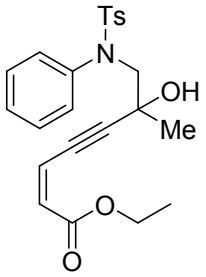
^{13}C NMR (125 MHz, $CDCl_3$): δ = 164.7 (C=O), 158.6, 129.6, 129.4, 122.5, 121.5, 115.1, 102.8, 80.8, 75.2, 67.8, 60.7, 25.9 and 14.4 ppm.

IR (neat): 3421 (OH), 2984, 2933, 2872, 2361, 2337, 1709(C=O), 1600, 1495, 1457, 1410, 1294, 1242, 1126 and 320 cm^{-1}.

HR ESI-MS:$[C_{16}H_{18}NaO_4]^+$ = $[M+Na]^+$ requires 297.1097; found 297.1092

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-hydroxy-6-methyl-7-[*N*-phenyl-*N*-(4-methyl-phenylsulfonamido)]hept-2-en-4-ynoate (12m)



12m

Iodo ester (116 mg, 0.5 mmol), alcohol **S_{16}** (130 mg, 0.4 mmol), dry THF (6 mL), dry DIPA (1 ml), CuI (12 mg, 0.06 mmol) and $PdCl_2(PPh_3)_2$ (3 mg, 0.004 mmol) were stirred for 12 h at 0 °C to RT. Purification by flash column chromatography (3:1 hexane:EtOAc) gave the hydroxyl-ester **12m** (140 mg, 0.33 mmol, 82%) as a pale red oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.43 (2 H, d, *J* = 8.4 Hz), 7.27-7.23 (5 H, m), 7.09 (2 H, d, *J* = 8.4 Hz), 5.96 (1 H, d, *J* = 11.4 Hz), 5.86 (1 H, d, *J* = 11.4 Hz), 4.15 (2 H, q, *J* = 7.1 Hz), 3.83 (2 H, s), 2.43 (3 H, s), 1.56 (3 H, s) and 1.27 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 164.6, 143.9, 141.0, 134.9, 129.6, 129.5, 129.4, 128.9, 128.7, 128.0, 127.9, 122.3, 103.3, 81.6, 68.3, 60.8, 60.5, 27.2, 21.6 and 14.3 ppm.

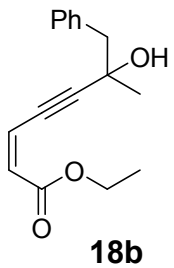
IR (neat): 3467 (OH), 2985, 2959, 2928, 2855, 2361, 1708 (C=O), 1600, 1452, 1407, 1347, 1303, 1187, 1162, 1024, 817 and 774 cm^{-1}.

HR ESI-MS:$[C_{23}H_{25}NaO_5S]^+$ = $[M+Na]^+$ requires 450.1346; found 450.1354

TLC: R_f = 0.4 (3:1, Hex/EtOAc).

(Z)-Ethyl 6-hydroxy-6-methyl-7-phenylhept-2-en-4-ynoate (18b)

Iodo ester (234 mg, 1.04 mmol), alcohol[6] (150 mg, 0.95 mmol), dry THF (5 mL), dry DIPA (2 ml), CuI (29 mg, 0.15 mmol) and $PdCl_2(PPh_3)_2$ (7 mg, 0.01 mmol) were stirred for 13 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **18b** (180 mg, 0.7 mmol, 74%) as a pale yellow oil.



18b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.36-7.26 (5 H, m), 6.12(1 H, d, *J* = 11.4 Hz), 6.04 (1 H, d, *J* = 11.4 Hz), 4.19 (2 H, q, *J* = 7.2 Hz), 3.08 (1 H, d, *J* = 13.3 Hz), 2.99 (1 H, d, *J* = 13.3 Hz), 1.88 (3 H, s) and 1.28 (3 H, t, *J* = 7.2 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 164.8, 136.3, 130.9, 128.8, 128.2, 127.1, 122.6, 105.1, 81.3, 68.7, 60.6, 49.4, 29.2 and 14.4 ppm.

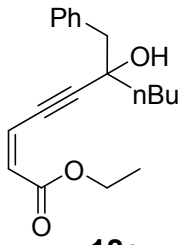
IR (neat): 3444 (OH), 2983, 2955, 2933, 2902, 1702 (C=O), 1600, 1512, 1440, 1296, 1235, 1188, 1075, 1032 and 830 cm^{-1}.

HR ESI-MS:$[C_{16}H_{18}NaO_3]^+$ = $[M+Na]^+$ requires 281.1148; found 281.1148

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

(*Z*)-Ethyl 6-benzyl-6-hydroxydec-2-en-4-ynoate (18e)

The iodo ester (232 mg, 1.03 mmol), alcohol **S_{17}**(160 mg, 0.79 mmol), dry THF (5 mL), dry DIPA (2 ml), CuI (22.5 mg, 0.12 mmol) and $PdCl_2(PPh_3)_2$ (5.5 mg, 0.008 mmol) were stirred for 13 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **18e** (180 mg, 0.6 mmol, 76%) as a pale yellow oil.



18e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.35-7.26 (5 H, m), 6.12 (1 H, d, *J* = 11.6 Hz), 6.07 (1 H, d, *J* = 11.6 Hz), 4.22 (2 H, q, *J* = 7.2 Hz), 3.09 (1 H, d, *J* = 13.2 Hz), 2.95 (1 H, d, *J* = 13.3 Hz), 1.75 (2 H, t, *J* = 7.8 Hz), 1.64-1.60 (2 H, m), 1.40-1.35 (2 H, m), 1.28 (3 H, t, *J* = 7.2 Hz) and 0.93 (3 H, t, *J* = 7.4 Hz) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ = 164.7, 136.2, 131.1, 128.8, 128.2, 127.0, 122.5, 104.4, 82.5, 71.8, 60.6, 48.1, 41.5, 26.6, 23.0, 20.8, 14.4 and 14.2 ppm.

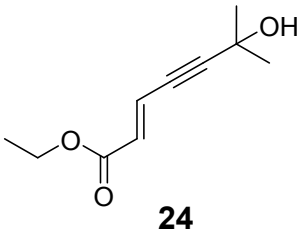
IR (neat): 3440 (OH), 2956, 2928, 2869, 2369, 1711 (C=O), 1605, 1563, 1455, 1409, 1386, 1318, 1225, 1186, 1029, 818 and 701 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_3]^+$ = $[M+Na]^+$ requires 323.1618; found 323.1618

TLC: R_f = 0.4 (4:1, Hex/EtOAc).

(*E*)-Ethyl 6-hydroxy-6-methylhept-2-en-4-ynoate (24)

Iodo ester[7] (225 mg, 1 mmol), alcohol (84 mg, 1 mmol), dry THF (7 mL), dry DIPA (2 ml), CuI (29 mg, 0.15 mmol) and $PdCl_2(PPh_3)_2$ (7 mg, 0.01 mmol) were stirred for 14 h at 0 °C to RT. Purification by flash Column chromatography (4:1 hexane:EtOAc) gave the hydroxyl-ester **24** (150 mg, 0.83 mmol, 83%) as a pale yellow oil.



24

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.76(1 H, d, *J* = 16.0 Hz), 6.20 (1 H, d, *J* = 16.0 Hz), 4.21 (2 H, q, *J* = 7.2 Hz), 1.56 (6 H, s) and 1.29 (3 H, t, *J* = 7.2 Hz) ppm.

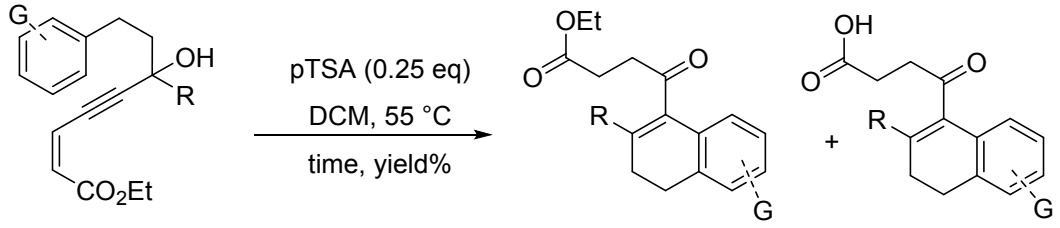
^{13}C NMR (100 MHz, $CDCl_3$): δ = 165.9, 130.6, 124.8, 102.9, 79.2, 65.7, 60.9, 31.2 and 14.3 ppm.

IR (neat): 3443 (OH), 2990, 2958, 2935, 2910, 1703 (OC=O), 1605, 1514, 1447, 1295, 1245, 1191, 1078, 1036 and 730 cm^{-1}.

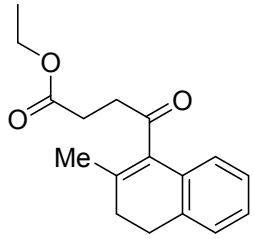
HR ESI-MS:$[C_{10}H_{14}NaO_3]^+ = [M+Na]^+$ requires 205.0835; found 205.0841

TLC: $R_f = 0.4$ (4:1, Hex/EtOAc)

Synthesis of bicyclic systems *via* developed intramolecular cascade arylation strategy:



Ethyl 4-(2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10a)



10a

The hydroxyl-ester **9a** (60 mg, 0.22 mmol) and pTSA (10.5 mg, 0.06 mmol), in DCM (5 mL) were stirred for 1.5 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the bicyclic 1,4-keto-ester **10a** (48 mg, 0.18 mmol, 80%) as a pale yellow oil. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **11a** (5.5 mg, 0.024 mmol, 10%) as a color less solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15-7.14 (3 H, m), 6.91-6.89 (1 H, m), 4.17 (2 H, q, *J* = 7.1 Hz), 2.98 (2 H, t, *J* = 6.6 Hz), 2.80 (2 H, t, *J* = 8.1 Hz), 2.67 (2 H, t, *J* = 6.5 Hz), 2.28 (2 H, t, *J* = 7.8 Hz), 1.91 (3 H, s) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.2, 172.8, 136.1, 135.6, 134.7, 132.1, 127.8, 127.0, 126.8, 123.6, 60.8, 38.8, 30.0, 28.1, 28.0, 20.7 and 14.4 ppm.

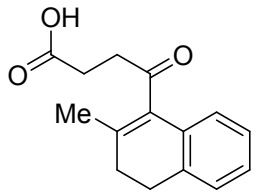
IR (neat): 3061, 2979, 2928, 2854, 1734 (OC=O), 1699 (C=O), 1490, 1374, 1347, 1206, 1150, 1097 and 765 cm^{-1}.

HR ESI-MS: $[C_{17}H_{21}O_3]^+ = [M+H]^+$ requires 273.1485; found 273.1487

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(2-Methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (11a)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.14-7.13 (3 H, m), 6.89-6.87 (1 H, m), 3.01 (2 H, t, *J* = 6.5 Hz), 2.81 (2 H, t, *J* = 7.8 Hz), 2.74 (2 H, t, *J* = 6.5 Hz), 2.28 (2 H, t, *J* = 7.8 Hz) and 1.91 (3 H, s) ppm.



11a

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 178.2, 136.5, 135.4, 134.7, 132.0, 127.8, 127.1, 126.8, 123.6, 38.4, 29.9, 27.9, 27.8 and 20.7 ppm.

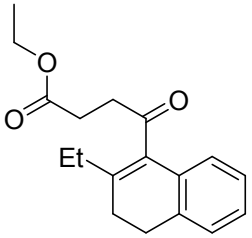
IR (neat): 3466, 2967, 2926, 2854, 1709 (C=O), 1691 (C=O), 1640, 1492, 1429, 1396, 1367, 1336, 1287, 1225, 1154, 1006, 930 and 817 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc)

M.P.: 97-99 °C

Ethyl 4-(2-ethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10b)

The hydroxyl-ester **9b** (40 mg, 0.14 mmol), and pTSA (6.6 mg, 0.04 mmol), in DCM (4 mL) were stirred for 1 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave bicyclic 1,4-keto-ester **10b** (31 mg, 0.11 mmol, 77.5%) as a pale yellow oil. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **11b** (6.5 mg, 0.025 mmol, 18%) as a color less solid.



10b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.17-7.14 (3 H, m), 6.91-6.90 (1 H, m), 4.17 (2 H, q, *J* = 7.1 Hz), 2.98 (2 H, t, *J* = 6.6 Hz), 2.78 (2 H, t, *J* = 8.1 Hz), 2.67 (2 H, t, *J* = 6.6 Hz), 2.29 (2 H, t, *J* = 7.6 Hz), 2.21 (2 H, q, *J* = 7.5 Hz), 1.28 (3 H, t, *J* = 7.1 Hz) and 1.10 (3 H, t, *J* = 7.5 Hz) ppm.

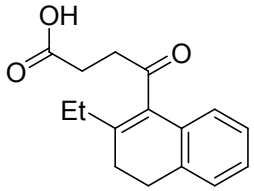
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 172.8, 141.6, 135.0, 134.9, 132.1, 127.7, 127.1, 126.8, 123.8, 60.8, 39.0, 28.2, 28.1, 27.8, 27.1, 14.3 and 13.0 ppm.

IR (neat): 3062, 2971, 2933, 2876, 2832, 1735 (OC=O), 1699 (C=O), 1490, 1397, 1346, 1205, 1148, 1035 and 765 cm^{-1}.

HR ESI-MS:$[C_{18}H_{23}O_3]^+ = [M+H]^+$ requires 287.1642; found 287.1655

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(2-Ethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (11b)



11b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15-7.13 (3 H, m), 6.88-6.86 (1 H, m), 2.98 (2 H, t, *J* = 6.4 Hz), 2.80 (2 H, t, *J* = 8.1 Hz), 2.74 (2 H, t, *J* = 6.3 Hz), 2.29 (2 H, t, *J* = 7.6 Hz), 2.21 (2 H, q, *J* = 7.6 Hz) and 1.09 (3 H, t, *J* = 7.5 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.9, 178.4, 141.9, 134.9, 134.8, 132.0, 127.7, 127.1, 126.8, 123.8, 38.7, 28.2, 27.7, 27.1 and 13.0 ppm.

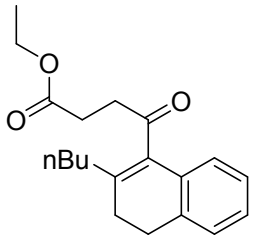
IR (neat): 3465, 2962, 2936, 2844, 1708 (C=O), 1693 (C=O), 1644, 1493, 1439, 1376, 1361, 1332, 1277, 1235, 1164, 1016, 938 and 819 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc)

M.P.: 139-141 °C

Ethyl 4-(2-butyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10c)

The hydroxyl-ester **9c** (40 mg, 0.13 mmol), and pTSA (6 mg, 0.03 mmol), in DCM (4 mL) were stirred for 1 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **10c** (32 mg, 0.10 mmol, 80%) as a pale yellow oil. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **11c** (6 mg, 0.02 mmol, 16%) as a colorless solid.



10c

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.28-7.10 (3 H, m), 6.91-6.89 (1 H, m), 4.16 (2 H, q, *J* = 7.2 Hz), 2.97 (2 H, t, *J* = 6.6 Hz), 2.78 (2 H, t, *J* = 8.2 Hz), 2.66 (2 H, t, *J* = 6.6 Hz), 2.27 (2 H, t, *J* = 7.6 Hz), 2.19 (2 H, q, *J* = 7.8 Hz), 1.50-1.42 (2 H, m), 1.39-1.32 (2 H, m), 1.27 (3 H, t, *J* = 7.2 Hz) and 0.91 (3 H, t, *J* = 7.2 Hz) ppm.

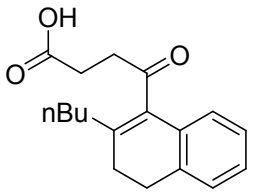
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 172.8, 140.4, 135.5, 135.0, 132.2, 127.7, 127.1, 126.8, 123.8, 60.8, 39.0, 34.4, 30.5, 28.2, 28.1, 27.6, 22.8, 14.3 and 14.1 ppm.

IR (neat): 3062, 2957, 2930, 2861, 1735 (OC=O), 1700 (C=O), 1600, 1491, 1374, 1346, 1202, 1148, 1030 and 763 cm^{-1}.

HR ESI-MS:$[C_{20}H_{27}O_3]^+ = [M+H]^+$ requires 315.1955; found 315.1958

TLC: $R_f = 0.4$ (9:1, Hex/EtOAc)

4-(2-Butyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (11c)



11c

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.14-7.13 (3 H, m), 6.88-6.86 (1 H, m), 2.88 (2 H, t, *J* = 6.4 Hz), 2.79 (2 H, t, *J* = 7.9 Hz), 2.73 (2 H, t, *J* = 6.4 Hz), 2.28 (2 H, t, *J* = 8.2 Hz), 2.19 (2 H, q, *J* = 7.8 Hz), 1.50-1.43 (2 H, m), 1.38-1.29 (2 H, m) and 0.91 (3 H, t, *J* = 7.2 Hz) ppm.

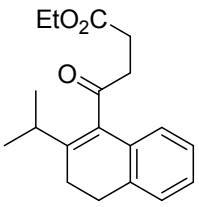
^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.9, 178.4, 140.7, 135.3, 135.0, 132.1, 127.7, 127.1, 126.8, 123.7, 38.7, 34.4, 30.5, 28.2, 27.7, 27.6, 22.9 and 14.1 ppm.

IR (neat): 3444, 2961, 2946, 2854, 1709 (C=O), 1695 (C=O), 1644, 1473, 1429, 1372, 1363, 1334, 1272, 1245, 1164, 1026, 938 and 817 cm^{-1}.

TLC: $R_f = 0.4$ (2:1, Hex/EtOAc).

M.P.: 95-97 °C

Ethyl 4-(2-isopropyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10d)



10d

The hydroxyl-ester **9d** (50 mg, 0.17 mmol), and pTSA (8 mg, 0.04 mmol), in DCM (5 mL) were stirred for 6.5 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **10d** (41 mg, 0.14 mmol, 81%) as a pale yellow oil. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **11c** (7 mg, 0.025 mmol, 14%) as a colorless solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.17-7.13 (3 H, m), 6.91-6.84 (1 H, m), 4.17 (2 H, q, *J* = 7.1 Hz), 2.97 (2 H, t, *J* = 6.6 Hz), 2.78-2.71 (3 H, m), 2.66 (2 H, t, *J* = 6.6 Hz), 2.23 (2 H, t, *J* = 7.6 Hz), 1.28 (3 H, t, *J* = 7.1 Hz) and 1.09 (6H, d, *J* = 6.73 Hz) ppm.

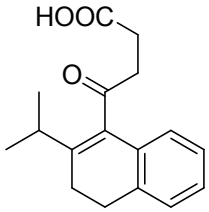
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.6, 172.8, 144.6, 135.2, 134.1, 132.0, 127.6, 127.1, 126.8, 123.7, 60.8, 39.3, 31.6, 28.4, 27.9, 21.5, 20.9 and 14.3 ppm.

IR (neat): 2962, 2929, 2853, 1736 (OC=O), 1701 (C=O), 1489, 1454, 1396, 1373, 1259, 1206, 1156, 1095, 803 and 765 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_3]^+$ = $[M+Na]^+$ requires 323.1618; found 323.1618

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(2-Isopropyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (11d)



11d

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.14-7.12 (3 H, m), 6.86-6.84 (1 H, m), 2.97 (2 H, t, *J* = 6.5 Hz), 2.78-2.68 (5 H, m), 2.24 (2 H, t, *J* = 7.6 Hz) and 1.08 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.4, 178.3, 144.9, 135.3, 134.1, 131.9, 127.6, 127.1, 126.8, 123.8, 39.1, 31.6, 28.4, 21.6 and 20.9 ppm.

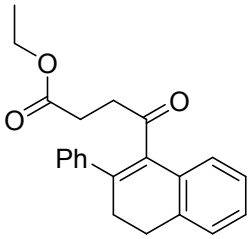
IR (neat): 3441, 2963, 2915, 2856, 1707 (C=O), 1685 (C=O), 1646, 1472, 1422, 1378, 1367, 1324, 1252, 1215, 1162, 1028, 935 and 813 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 170-172 °C.

Ethyl 4-oxo-4-(2-phenyl-3,4-dihydronaphthalen-1-yl)butanoate (10e)

The hydroxyl-ester **9e** (35 mg, 0.1 mmol), and MsOH (2.5 mg, 0.03 mmol, 0.18 mL of 14 *M* in DCM), in DCM (3 mL) were stirred for 45 min at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **10e** (29 mg, 0.09 mmol, 83%) as a pale yellow oil.



10e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.38-7.28 (6 H, m),7.19-7.18 (2 H, m), 7.14-7.12 (1 H, m), 4.08 (2 H, q, *J* = 7.2 Hz), 2.96 (2 H, t, *J* = 8.5 Hz), 2.74 (2 H, t, *J* = 7.5 Hz), 2.53 (2 H, t, *J* = 6.6 Hz), 2.37 (2 H, t, *J* = 6.8 Hz) and 1.22 (3 H, t, *J* = 7.2 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.8, 172.7, 150.1, 141.1, 138.6, 137.3, 135.0, 132.1, 128.8, 128.3, 127.9, 127.8, 127.0, 124.7, 60.7, 39.4, 29.8, 28.4, 28.3 and 14.3 ppm.

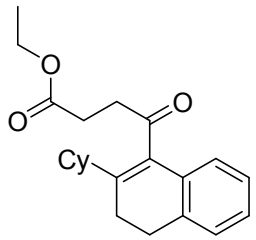
IR (neat): 3058, 2957, 2925, 2851, 1734 (OC=O), 1698 (C=O), 1600, 1489, 1372, 1348, 1252, 1205, 1162, 1029 and 763 cm^{-1}.

HR ESI-MS:$[C_{22}H_{23}O_3]^+ = [M+H]^+$ requires 335.1642; found 335.1646.

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

Ethyl 4-(2-cyclohexyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10f)

The hydroxyl-ester **9f** (60 mg, 0.18 mmol), and pTSA (9 mg, 0.05 mmol), in DCM (6 mL) were stirred for 45 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **10f** (38 mg, 0.12 mmol, 65%) as a pale yellow solid. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **11f** (10 mg, 0.04 mmol, 23%) as a colorless solid.



10f

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.18-7.10 (3 H, m), 6.89-6.87 (1 H, m), 4.18 (2 H, q, *J* = 7.1 Hz), 2.96 (2 H, t, *J* = 6.6 Hz), 2.75 (2 H, t, *J* = 8.1 Hz), 2.67 (2 H, t, *J* = 6.6 Hz), 2.33 (1 H, tt, *J* = 11.3 & 8.1 Hz), 2.50 (2 H, t, *J* = 7.6 Hz), 1.78-1.60 (6 H, m), 1.45-1.32 (4 H, m) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.6, 172.8, 144.1, 135.3, 134.5, 132.0, 127.6, 127.1, 126.8, 123.8, 60.8, 42.7, 39.5, 30.8, 28.4, 28.1, 26.2, 26.1, 23.0 and 14.4 ppm.

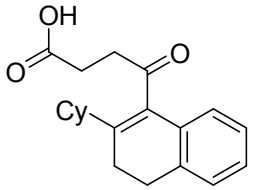
IR (neat): 3016, 2976, 2927, 2853, 2359, 1730 (OC=O), 1700 (C=O), 1489, 1450, 1373, 1346, 1255, 1204, 1163, 1148, 1032 and 764 cm^{-1}.

HR ESI-MS:$[C_{22}H_{29}O_3]^+ = [M+H]^+$ requires 341.2111; found 341.2113

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

M.P.: 65-67 °C

4-(2-Cyclohexyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (11f)



11f

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.14-7.12 (3 H, m), 6.86-6.84 (1 H, m), 2.96 (2 H, t, *J* = 6.5 Hz), 2.77-2.73 (4 H, m), 2.62 (1 H, tt, *J* = 11.4 & 8.1 Hz), 2.25 (2 H, t, *J* = 7.6 Hz), 1.77-1.61 (6 H, m), and 1.44-1.28 (4 H, m) ppm

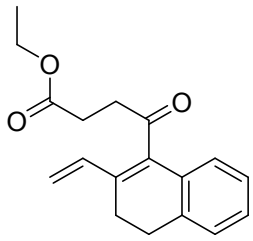
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.4, 178.0, 144.3, 135.3, 134.3, 131.9, 127.7, 127.1, 126.8, 123.7, 42.6, 39.2, 30.9, 28.4, 27.7, 26.1 and 23.0 ppm.

IR (neat): 3451, 2953, 29465, 2856, 1709 (C=O), 1695 (C=O), 1646, 1472, 1432, 1378, 1347, 1324, 1272, 1225, 1162, 1038, 957 and 821 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 149-151 °C

Ethyl 4-oxo-4-(2-vinyl-3,4-dihydronaphthalen-1-yl)butanoate (10g)



10g

The hydroxyl-ester **9g** (30 mg, 0.11 mmol), and pTSA (5 mg, 0.03 mmol), in DCM (3 mL) were stirred for 1 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **10g** (14 mg, 0.05 mmol, 47%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.9-7.17 (3 H, m), 6.99-6.94 (1 H, m), 6.58 (1 H, dd, *J* = 17.1 & 10.3 Hz), 5.51 (1H, d, *J* = 16.8 Hz), 5.29 (1 H, d, *J* = 10.9 Hz), 4.18 (2 H, q, *J* = 7.1 Hz), 3.02 (2 H, t, *J* = 6.6 Hz), 2.86 (2 H, t, *J* = 7.6 Hz), 2.69 (2 H, t, *J* = 6.4 Hz), 2.52 (2 H, t, *J* = 8.3 Hz) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm.

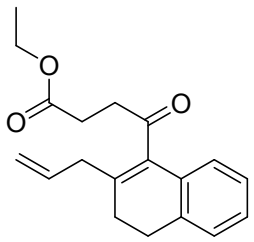
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.2, 172.7, 138.4, 135.9, 134.0, 133.9, 131.8, 128.7, 128.5, 128.0, 127.8, 126.9, 124.7, 116.7, 116.4, 60.9, 39.4, 28.0, 27.8, 22.6 and 14.4 ppm.

IR (neat): 2975, 2926, 2857, 1732 (OC=O), 1701 (C=O), 1600, 1548, 1568, 1485, 1443, 1395, 1377, 1258, 1206, 1160, 1094, 1026, 921 and 764 cm^{-1}.

HR ESI-MS:$[C_{18}H_{20}NaO_3]^+$ = $[M+Na]^+$ requires 307.1305; found 307.1308

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

Ethyl 4-(2-allyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (10h)



10h

The hydroxyl-ester **9h** (35 mg, 0.12 mmol), and pTSA (5.5 mg, 0.03 mmol), in DCM (3 mL) were stirred for 2.5 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **10h** (28 mg, 0.09 mmol, 80%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.17-7.14 (3 H, m), 6.96-6.90 (1 H, m), 5.87-5.77 (1 H, m), 5.19-5.08 (2 H, m), 4.17 (2 H, q, *J* = 7.1 Hz), 3.02-2.95 (4 H, m), 2.80 (2 H, t, *J* = 8.3 Hz), 2.66 (2 H, t, *J* = 6.5 Hz), 2.29 (2 H, t, *J* = 7.74 Hz) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

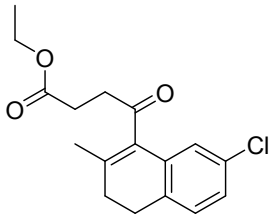
^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.9, 172.8, 137.2, 136.6, 135.1, 132.0, 127.8, 127.4, 127.3, 126.9, 124.0, 117.0, 60.8, 39.0, 38.6, 28.1, 28.0, 27.4 and 14.4 ppm.

IR (neat): 2972, 2926, 2857, 1730 (OC=O), 1699 (C=O), 1600, 1448, 1377, 1258, 1206, 1160, 1094, 1026, 921 and 764 cm^{-1}.

HR ESI-MS:$[C_{19}H_{23}O_3]^+ = [M+H]^+$ requires 299.1642; found 299.1652

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

Ethyl 4-(7-chloro-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13a)



13a

The hydroxyl-ester **12a** (60 mg, 0.2 mmol), and MsOH (12.2 mg, 0.13 mmol, 0.1 mL of 1.4 *M* in DCM), in DCM (5 mL) were stirred for 45 min at 0 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **13a** (36 mg, 0.12 mmol, 60%) as a pale yellow oil. Further elution with 3:2 hexane-EA mixture afforded the keto-acid **14a** (13 mg, 0.046mmol, 23%) as a colorless solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.11-7.05 (2 H, m), 6.89 (1 H, d, *J* = 1.8 Hz), 4.18 (2 H, q, *J* = 7.1 Hz), 2.97 (2 H, t, *J* = 6.5 Hz), 2.76 (2 H, t, *J* = 8.1 Hz), 2.68 (2 H, t, *J* = 6.5 Hz), 2.28 (2 H, t, *J* = 7.8 Hz), 1.92 (3 H, s) and 1.29 (3 H, t, *J* = 7.1 Hz) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.6, 172.7, 137.8, 134.9, 133.6, 133.0, 132.4, 128.9, 126.9, 123.6, 60.9, 40.0, 29.9, 28.1, 27.4, 20.8 and 14.4 ppm.

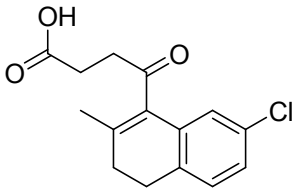
IR (neat): 2976, 2928, 2855, 1733 (OC=O), 1699 (C=O), 1595, 1483, 1433, 1399, 1372, 1262, 1206, 1158, 1098, 937 and 736 cm^{-1}.

HR ESI-MS:$[C_{17}H_{20}ClO_3]^+ = [M+H]^+$ requires 307.1095; found 307.1112

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(7-Chloro-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14a)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.11-7.05 (2 H, m), 6.91 (1 H, d, *J* = 1.8 Hz), 2.97 (2 H, t, *J* = 6.5 Hz), 2.79-2.74 (4 H, m), 2.28 (2 H, t, *J* = 8.1 Hz), and 1.91 (3 H, s) ppm



14a

^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.3, 177.7, 137.9, 134.7, 133.5, 132.9, 132.4, 128.9, 126.9, 123.6, 38.5, 29.9, 27.6, 27.3 and 20.8 ppm.

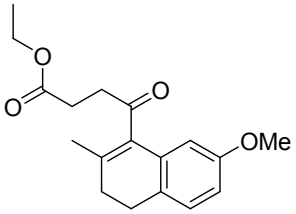
IR (neat): 3445, 2972, 2926, 2855, 1707 (C=O), 1696 (C=O), 1646, 1433, 1422, 1398, 1347, 1324, 1252, 1225, 1162, 1028, 935 and 763 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 165-167 °C

Ethyl 4-(7-methoxy-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13b)

The hydroxyl-ester **12b** (60 mg, 0.2 mmol), and MsOH (2.4 mg, 0.03 mmol, 0.18 mL of 14 *M* in DCM), in DCM (5 mL) were stirred for 45 min at 0 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **13b** (36 mg, 0.12 mmol, 60%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14b** (14 mg, 0.05 mmol, 25%) as a color less solid.



13b

NMR (400 MHz, $CDCl_3$): δ = 7.04 (1 H, d, *J* = 8.0 Hz), 6.68 (1 H, d, *J* = 6.5 Hz), 6.52 (1 H, s), 4.16 (2 H, q, *J* = 7.1 Hz), 3.76 (3 H, s), 2.98 (2 H, t, *J* = 6.1 Hz), 2.73 (2 H, t, *J* = 7.9 Hz), 2.66 (2 H, t, *J* = 6.1 Hz), 2.26 (2 H, t, *J* = 7.3 Hz), 1.90 (3 H, s) and 1.27 (3 H, t, *J* = 7.1 Hz) ppm.

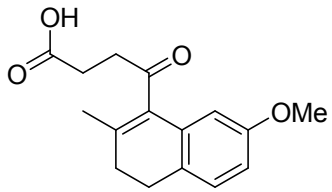
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 172.8, 158.6, 136.7, 135.6, 133.0, 128.3, 126.8, 112.1, 109.9, 60.8, 55.5, 38.8, 30.4, 28.0, 27.1, 20.7 and 14.3 ppm.

IR (neat): 2976, 2930, 2834, 1733 (OC=O), 1699 (C=O), 1606, 1575, 14991374, 1305, 1213, 1160, 1096, 1027and 810 cm^{-1}.

HR ESI-MS:$[C_{18}H_{23}O_4]^+$ = $[M+H]^+$ requires 303.1591; found 303.1584

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(7-Methoxy-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14b)



14b

NMR (400 MHz, $CDCl_3$): δ = 7.04 (1 H, d, *J* = 8.0 Hz), 6.68 (1 H, d, *J* = 6.5 Hz), 6.52 (1 H, S), 3.75 (3 H, s), 3.01 (2 H, t, *J* = 6.2 Hz), 2.75-2.70 (4 H, m), 2.26 (2 H, t, *J* = 7.7 Hz) and 1.89 (3 H, s) ppm.

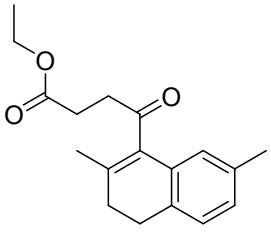
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.0, 178.0, 158.5, 137.0, 135.4, 132.9, 128.4, 126.8, 112.2, 109.6, 55.5, 38.4, 30.4, 29.8, 27.6, 27.1 and 20.7 ppm.

IR (neat): 3451, 2963, 2928, 2854, 1708 (C=O), 1684 (C=O), 1644, 1462, 1425, 1379, 1357, 1326, 1255, 1225, 1152, 1038, 955 and 839 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 94-96 °C

Ethyl 4-(2,7-dimethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13c)



13c

The hydroxyl-ester **12c** (50 mg, 0.18 mmol), and pTSA (4 mg, 0.02 mmol), in DCM (4 mL) were stirred for 1.5 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester

13c (38 mg, 0.13 mmol, 76%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14c** (8 mg, 0.03 mmol, 16%) as a color less solid.

NMR (400 MHz, $CDCl_3$): δ = 7.03 (1 H, d, *J* = 7.5 Hz), 6.95 (1 H, d, *J* = 7.5 Hz), 6.71 (1 H, S), 4.17 (2 H, q, *J* = 7.1 Hz), 2.99 (2 H, t, *J* = 6.7 Hz), 2.76 (2 H, t, *J* = 8.1 Hz), 2.66 (2 H, t, *J* = 6.7 Hz), 2.37-2.29 (5 H, m), 1.90 (3 H, s) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.4, 172.8, 136.2, 135.9, 135.7, 131.9, 131.6, 127.6, 127.5, 124.3, 60.8, 38.9, 30.2, 28.2, 27.6, 21.3, 20.7 and 14.4 ppm.

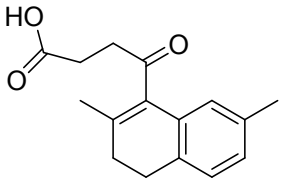
IR (neat): 2976, 2922, 2851, 1735 (OC=O), 1699 (C=O), 1608, 1499, 1441, 1374, 1199, 1157, 1021 and 813 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 309.1461; found 309.1465

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(2,7-Dimethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14c)

NMR (400 MHz, $CDCl_3$): δ = 7.02 (1 H, d, *J* = 7.5 Hz), 6.94 (1 H, d, *J* = 7.5 Hz), 6.71 (1 H, S), 2.99 (2 H, t, *J* = 6.7 Hz), 2.37-2.74 (4 H, m), 2.28-2.25 (5 H, m) and 1.89 (3 H, s) ppm.



14c

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 178.3, 147.5, 136.3, 135.6, 132.1, 131.9, 127.6, 124.9, 122.1, 38.4, 34.0, 30.2, 27.6, 24.1 and 20.7 ppm.

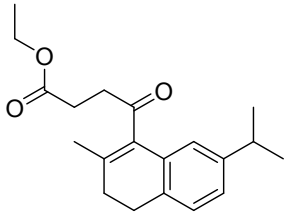
IR (neat): 3441, 2953, 2945, 2856, 1709 (C=O), 1689 (C=O), 1644, 1472, 1432, 1379, 1368, 1324, 1258, 1215, 1172, 1028, 945 and 817 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 99-100 °C

Ethyl 4-(7-isopropyl-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13d)

The hydroxyl-ester **12d** (50 mg, 0.18 mmol), and pTSA (8.3 mg, 0.043 mmol), in DCM (4 mL) were stirred for 60 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-



13d

ester **13d** (42 mg, 0.15 mmol, 84%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14d** (6 mg, 0.02 mmol, 12%) as a color less solid.

NMR (400 MHz, $CDCl_3$): δ = 7.07 (1 H, d, *J* = 7.7 Hz), 7.01 (1 H, d, *J* = 7.7 Hz), 6.76 (1 H, s), 4.17 (2 H, q, *J* = 7.1 Hz), 2.99 (2 H, t, *J* = 6.5 Hz), 2.84 (1 H, q, *J* = 6.9 Hz), 2.77 (2 H, t, *J* = 8.2 Hz), 2.68 (2 H, t, *J* = 6.5 Hz),2.26 (2 H, t, *J* = 7.7 Hz), 1.91 (3 H, s), 1.28 (3 H, t, *J* = 7.1 Hz)and 1.21 (6 H, d, *J* = 6.9 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.4, 172.8, 147.4, 136.1, 135.7, 132.1, 131.9, 131.9, 127.6, 124.8, 122.0, 60.7, 38.7, 34.0, 30.1, 28.1, 27.6, 24.1, 20.7 and 14.3 ppm.

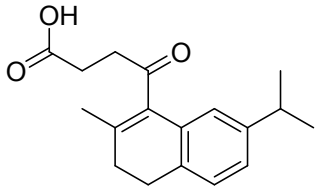
IR (neat): 2979, 2925, 2829, 1735 (OC=O), 1700 (C=O), 1608, 1469, 1375, 1348, 1259, 1204, 1155, 1093, 1026 and 786 cm^{-1}.

HR ESI-MS:$[C_{20}H_{26}NaO_3]^+$ = $[M+Na]^+$ requires 337.1780; found 337.1781

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(7-Isopropyl-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14d)

NMR (400 MHz, $CDCl_3$): δ = 7.07 (1 H, d, *J* = 7.7 Hz), 7.01 (1 H, d, *J* = 7.7 Hz), 6.77 (1 H, s), 2.99 (2 H, t, *J* = 6.4 Hz), 2.85-2.73 (5 H, m), 2.27 (2 H, t, *J* = 7.7 Hz), 1.89 (3 H, s) and 1.20 (3 H, t, *J* = 7.0 Hz) ppm



14d

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.3, 178.4, 135.8, 135.7, 135.2, 133.0, 131.7, 129.2, 126.1, 121.7, 38.4, 29.7, 23.9, 20.6 and 19.8 ppm.

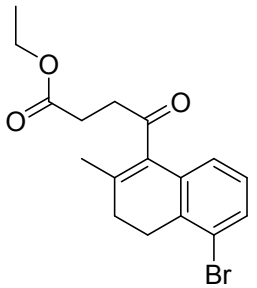
IR (neat): 3451, 2963, 2925, 2854, 1709 (C=O), 1695 (C=O), 1646, 1472, 1422, 1358, 1367, 1324, 1262, 1215, 1142, 1028, 938 and 817 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 150-152 °C

Ethyl 4-(5-bromo-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13e)

The hydroxyl-ester **12e** (40 mg, 0.12 mmol), and MsOH (22 mg, 0.24 mmol, 0.16 mL of 1.4 *M* in DCM), in DCM (3 mL) were stirred for 15 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4- keto-ester **13e** (24 mg, 0.07 mmol, 60%) as a pale red oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14e** (8 mg, 0.025 mmol, 20%) as a color less solid.



13e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.37 (1 H, d, *J* = 8.0 Hz), 7.02 (1 H, t, *J* = 8.0 Hz), 6.86 (1 H, d, *J* = 7.5 Hz), 4.18 (2 H, q, *J* = 7.1 Hz), 2.98-2.92 (4 H, m), 2.66 (2 H, t, *J* = 6.4 Hz), 2.31 (2 H, t, *J* = 8.0 Hz), 1.92 (3 H, s) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

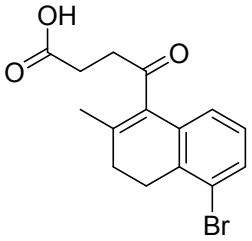
^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.6, 172.8, 137.1, 135.2, 134.1, 134.0, 131.3, 127.9, 124.1, 122.9, 60.9, 38.8, 29.6, 28.0, 27.5, 20.6 and 14.4 ppm.

IR (neat): 2978, 2927, 2852, 1733 (C=O), 1701 (C=O), 1456, 1438, 1357, 1348, 1205, 1160, 1107, 1024 and 784 cm^{-1}.

HR ESI-MS:$[C_{17}H_{19}BrNaO_3]^+$ = $[M+Na]^+$ requires 373.0410; found 373.0389

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(5-Bromo-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14e)



14e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.38 (1 H, d, *J* = 8.0 Hz), 7.01 (1 H, t, *J* = 8.0 Hz), 6.83 (1 H, d, *J* = 7.5 Hz), 2.95-2.92 (4 H, m), 2.73 (2 H, t, *J* = 6.4 Hz), 2.31 (2 H, t, *J* = 7.8 Hz) and 1.92 (3 H, s) ppm

^{13}C NMR (100 MHz, $CDCl_3$): δ = 206.5, 177.8, 134.7, 135.0, 134.1, 133.9, 131.3, 127.9, 124.1, 122.8, 38.5, 29.8, 29.5, 27.6, 27.4 and 20.6 ppm.

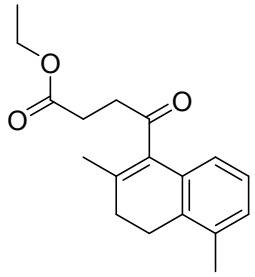
IR (neat): 3455, 2972, 2926, 2855, 1709 (C=O), 1694 (C=O), 1644, 1433, 1432, 1399, 1347, 1324, 1242, 1215, 1132, 1022, 942 and 783 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 109-111 °C

Ethyl 4-(2,5-dimethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13f)

The hydroxyl-ester **12f** (50 mg, 0.16 mmol), and pTSA (8 mg, 0.04 mmol), in DCM (4 mL) were stirred for 60 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **13f** (39 mg, 0.13 mmol, 78%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14f** (6.5 mg, 0.025 mmol, 16%) as a color less solid.



13f

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.06-7.01 (2 H, m), 6.74 (1 H, d, *J* = 6.9 Hz), 4.16 (2 H, q, *J* = 7.1 Hz), 2.96 (2 H, t, *J* = 6.6 Hz), 2.74 (2 H, t, *J* = 8.2 Hz), 2.65 (2 H, t, *J* = 6.6 Hz), 2.2 8-2.24 (5 H, m), 1.91 (3 H, s) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

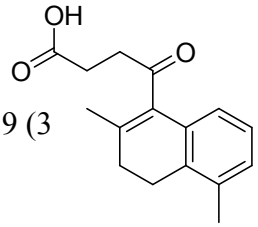
^{13}C NMR (100 MHz, $CDCl_3$): δ = 2067.5, 172.8, 135.8, 135.3, 135.1, 132.9, 131.8, 129.1, 126.1, 121.6, 60.7, 38.7, 29.6, 28.0, 23.8, 20.5, 19.7 and 14.3 ppm.

IR (neat): 2960, 2929, 2830, 1733 (OC=O), 1700 (C=O), 1607, 1499, 1462, 1417, 1375, 1259, 1201, 1154, 1098, 1022 and 824 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 309.1461; found 309.1468

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(2,5-Dimethyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14f)



14f

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.11-7.01 (2 H, m), 6.72 (1 H, d, *J* = 6.9 Hz), 2.96 (2 H, t, *J* = 6.5 Hz), 2.76-2.71 (4 H, m), 2.2 8-2.24 (5 H, m) and 1.89 (3 H, s) ppm.

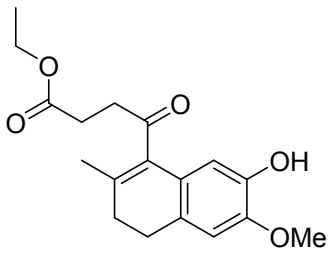
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 178.3, 147.5, 136.3, 135.6, 132.1, 131.9, 127.6, 124.9, 122.1, 38.4, 34.0, 30.2, 27.6, 24.1 and 20.7 ppm.

IR (neat): 3441, 2955, 2935, 2846, 1702 (C=O), 1685 (C=O), 1645, 1473, 1434, 1377, 1364, 1325, 1255, 1215, 1173, 1028, 955 and 813 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 94-16 °C

Ethyl 4-(7-hydroxy-6-methoxy-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13g)



13g

The hydroxyl-ester **12g** (40 mg, 0.12 mmol), and MsOH (3 mg, 0.03 mmol, 0.11 ml of 14 *M* in DCM), DCM (4 mL) were stirred for 100 min at 0 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **13g** (24 mg, 0.08 mmol, 60%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.67 (1 H, s), 6.51 (1 H, s), 4.17 (2 H, q, *J* = 7.1 Hz), 3.88 (3 H, s), 2.97 (2 H, t, *J* = 6.6 Hz), 2.72 (2 H, t, *J* = 8.2 Hz), 2.66 (2 H, t, *J* = 6.6 Hz), 2.24 (2 H, t, *J* = 7.6 Hz), 1.88 (3 H, s) and 1.28 (3 H, t, *J* = 7.1 Hz) ppm.

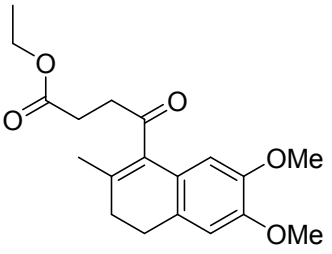
^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.2, 172.9, 145.4, 144.1, 135.1, 134.1, 126.7, 125.3, 110.8, 110.6, 60.8, 56.2, 38.8, 30.2, 28.1, 27.8, 20.6 and 14.4 ppm.

IR (neat): 3434, 2924, 2852, 2361, 1731 (OC=O), 1702 (C=O), 1599, 1512, 1264, 1104, 1023 and 798 cm^{-1}.

HR ESI-MS:$[C_{18}H_{22}NaO_5]^+$ = $[M+Na]^+$ requires 341.1359; found 341.1377

TLC: R_f = 0.4 (7:1, Hex/EtOAc)

Ethyl 4-(6,7-dimethoxy-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoate (13h)



13h

The hydroxyl-ester **12h** (50 mg, 0.15 mmol), and pTSA (7.2 mg, 0.04 mmol), in DCM (5 mL) were stirred for 100 min at 55 °C. Purification by flash Column chromatography (8:1 hexanes:EtOAc) gave 1,4-keto-ester **13h** (35 mg, 0.11 mmol, 70%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14h** (9 mg, 0.03 mmol, 20%) as a color less solid.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.68 (1 H, s), 6.59 (1 H, s), 4.14 (2 H, q, *J* = 7.1 Hz), 3.86 (3 H, s), 3.83 (3 H, s), 2.97 (2 H, t, *J* = 6.5 Hz), 2.72 (2 H, t, *J* = 7.6 Hz), 2.65 (2 H, t, *J* = 6.5 Hz), 2.23 (2 H, t, *J* = 8.2 Hz), 1.87 (3 H, s) and 1.26 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 207.4, 172.8, 147.8, 147.5, 135.1, 133.7, 127.2, 124.6, 111.4, 108.0, 60.7, 56.3, 56.1, 38.7, 30.1, 27.9, 27.7, 20.5 and 14.3 ppm.

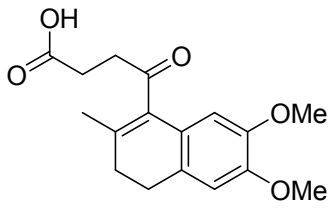
IR (neat): 3441, 2934, 2854, 2359, 1733 (OC=O), 1700 (C=O), 1600, 1512, 1437, 1262, 1108, 1023, 938 and 769 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_5]^+$ = $[M+Na]^+$ requires 355.1516; found 355.1525

TLC: R_f = 0.4 (8:1, Hex/EtOAc)

4-(6,7-Dimethoxy-2-methyl-3,4-dihydronaphthalen-1-yl)-4-oxobutanoic acid (14h)

^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.69 (1 H, s), 6.56 (1 H, s), 3.87 (3 H, s), 3.81 (3 H, s), 2.98 (2 H, t, *J* = 5.9 Hz), 2.75-2.71 (4 H, m), 2.25 (2 H, t, *J* = 8.2 Hz) and 1.87 (3 H, s) ppm.



14h

^{13}C NMR (125 MHz, $CDCl_3$): δ = 207.4, 177.8, 147.8, 147.5, 135.1, 133.7, 127.2, 124.6, 111.4, 108.0, 56.3, 56.1, 38.7, 30.1, 27.9, 27.7 and 20.5 ppm.

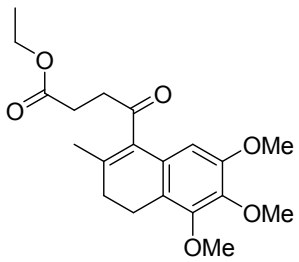
IR (neat): 3451, 2954, 2943, 2854, 1708 (C=O), 1685(C=O), 1648, 1445, 1412, 1369, 1348, 1314, 1248, 1211, 1173, 1023, 963 and 813 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 92-94 °C

Ethyl 4-oxo-4-(5,6,7-trimethoxy-2-methyl-3,4-dihydronaphthalen-1-yl)butanoate (13i)

The hydroxyl-ester **12i** (40 mg, 0.11 mmol), and MsOH (3 mg, 0.026 mmol, 0.1 mL of 14 M in DCM), in DCM (4 mL) were stirred for 55 min at 0 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **13i** (28 mg, 0.08 mmol, 70%) as



13i

a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14i** (6 mg, 0.017 mmol, 15%) as a color less solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.51 (1 H, s), 4.14 (2 H, q, *J* = 7.1 Hz), 3.86 (3 H, s), 3.84 (3 H, s), 3.58 (3 H, s), 2.82 (2 H, br s), 2.71-2.66 (4 H, m), 2.22 (2 H, t, *J* = 7.9 Hz), 1.91 (3 H, s) and 1.26 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 204.6, 173.5, 152.4, 148.9, 135.8, 132.1, 131.8, 120.5, 114.2, 107.7, 61.3, 61.1, 60.6, 56.2, 37.8, 30.6, 29.1, 28.7, 20.2 and 14.4 ppm.

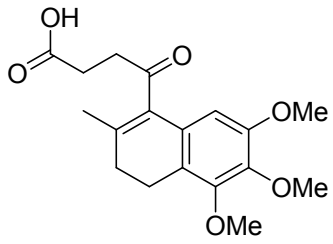
IR (neat): 2923, 2852, 1739 (C=O), 1695 (OC=O), 1596, 1488, 1461, 1408, 1366, 1314, 1260, 1123, 1019 and 798 cm^{-1}.

HR ESI-MS: $[C_{20}H_{26}O_6]^+ = [M+H]^+$ requires 385.1622; found 385.1599

TLC: R_f = 0.4 (9:1, Hex/EtOAc).

4-Oxo-4-(5,6,7-trimethoxy-2-methyl-3,4-dihydronaphthalen-1-yl)butanoic acid (14i)

^{1}HNMR (400 MHz, $CDCl_3$): δ = 6.53(1 H, s), 3.86 (3 H, s), 3.84 (3 H, s), 3.59 (3 H, s), 2.82 (2 H, br s), 2.71-2.66 (4 H, m), 2.23 (2 H, t, *J* = 7.5 Hz) and 1.91 (3 H, s) ppm.



14i

^{13}C NMR (100 MHz, $CDCl_3$): δ = 204.6, 177.3, 152.4, 148.9, 140.8, 135.8, 131.8, 120.5, 114.2, 107.7, 61.3, 60.6, 56.2, 37.8, 30.6, 28.9, 28.6 and 20.2 ppm.

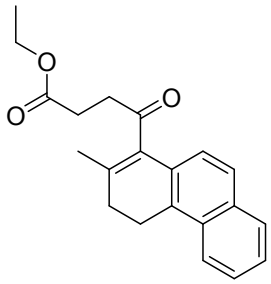
IR (neat): 3451, 2954, 2925, 2854, 1710 (C=O), 1695(C=O), 1645, 1442, 1412, 1378, 1378, 1324, 1248, 1205, 1162, 1038, 942 and 815 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 110-112 °C

Ethyl 4-(2-methyl-3,4-dihydrophenanthren-1-yl)-4-oxobutanoate (13j)

The hydroxyl-ester **12j** (60 mg, 0.19 mmol), and pTSA (9 mg, 0.05 mmol), in DCM (5 mL) were stirred for 50 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **13j** (51 mg, 0.16 mmol, 85%) as a pale yellow solid. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **14j** (5 mg, 0.017mmol, 11%) as a colorless solid.



13j

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.04 (1 H, d, *J* = 8.5 Hz), 7.79 (1 H, d, *J* = 8.0 Hz), 7.68 (1 H, d, *J* = 8.4 Hz), 7.51 (1 H, t, *J* = 7.7 Hz), 7.43 (1 H, t, *J* = 7.18 Hz), 7.13 (1 H, d, *J* = 8.5 Hz), 4.21 (2 H, q, *J* = 7.1 Hz), 3.23 (2 H, t, *J* = 8.3 Hz), 2.99 (2 H, t, *J* = 6.4 Hz), 2.70 (2 H, t, *J* = 6.4 Hz), 2.42 (2 H, t, *J* = 8.1 Hz), 1.99 (3 H, s) and 1.30 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.2, 172.8, 136.1, 136.0, 132.9, 131.4, 129.9, 129.1, 128.7, 126.7, 126.3, 125.4, 123.5, 122.6, 60.8, 38.9, 29.8, 28.1, 23.1, 20.5 and 14.3 ppm.

IR (neat): 3061, 2977, 2927, 2356, 1732 (OC=O), 1698 (C=O), 1382, 1352, 1024, 1160, 1029, 819 and 748 cm^{-1}.

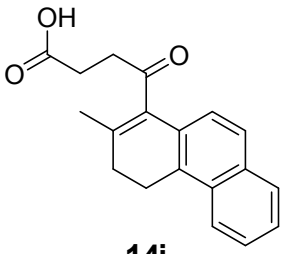
HR ESI-MS:$[C_{21}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 345.1464; found 345.1472

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

M.P.: 91-93 °C

4-(2-Methyl-3,4-dihydrophenanthren-1-yl)-4-oxobutanoic acid (14j)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.04 (1 H, d, *J* = 8.5 Hz), 7.79 (1 H, d, *J* = 8.0 Hz), 7.67 (1 H, d, *J* = 8.4 Hz), 7.51 (1 H, t, *J* = 7.7 Hz), 7.43 (1 H, t, *J* = 7.18 Hz), 7.13 (1 H, d, *J* = 8.5 Hz), 3.23 (2 H, t, *J* = 8.3 Hz), 2.99 (2 H, t, *J* = 6.4 Hz), 2.76 (2 H, t, *J* = 6.2 Hz), 2.42 (2 H, t, *J* = 8.5 Hz) and 1.98 (3 H, s) ppm



14j

^{13}C NMR (100 MHz, $CDCl_3$): δ = 207.1, 178.3, 136.4, 135.9, 131.4, 130.1, 129.1, 128.7, 126.8, 126.4, 125.4, 123.6, 122.6, 38.6, 29.8, 23.2 and 20.5 ppm.

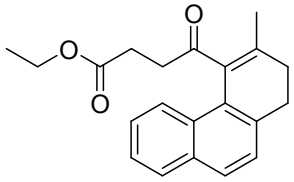
IR (neat): 3441, 2953, 2945, 2856, 1709 (C=O), 1689(C=O), 1644, 1472, 1432, 1379, 1368, 1324, 1258, 1215, 1172, 1028, 945 and 817 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 175-177 °C

Ethyl 4-(3-methyl-1,2-dihydrophenanthren-4-yl)-4-oxobutanoate (13k)

The hydroxyl-ester **12k** (50 mg, 0.16 mmol), and pTSA (7.4 mg, 0.04 mmol), in DCM (5 mL) were stirred for 90 min at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **13k** (42 mg, 0.13 mmol, 82%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixtures afforded the keto-acid **14k** (6 mg, 0.02 mmol, 12%) as a color less solid.



13k

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.80-7.78 (1 H, m), 7.73-7.69 (2 H, m), 7.40-7.35 (3 H, m), 4.08 (2 H, q, *J* = 7.2 Hz), 2.85 (2 H, t, *J* = 7.8 Hz), 2.55-2.49 (4 H, m), 2.30 (2 H, t, *J* = 7.8 Hz), 2.16 (3 H, s) and 1.22 (3 H, t, *J* = 7.2 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 205.8, 172.8, 143.6, 135.8, 134.8, 133.2, 129.9, 129.3, 128.9, 127.7, 126.5, 126.2, 124.9, 123.9, 60.5, 37.8, 31.5, 29.5, 28.7, 20.8 and 14.2 ppm.

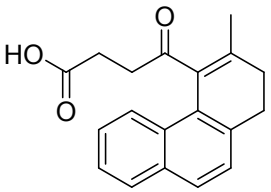
IR (neat): 3061, 2983, 2928, 2346, 1733 (OC=O), 1699 (C=O), 1382, 1352, 1024, 1160, 1029, 819 and 748 cm^{-1}.

HR ESI-MS:$[C_{21}H_{22}NaO_3]^+$ = $[M+Na]^+$ requires 345.1464; found 345.1471

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-(3-Methyl-1,2-dihydrophenanthren-4-yl)-4-oxobutanoic acid (14k)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.82-7.79 (1 H, m), 7.73-7.69 (2 H, m), 7.39-7.36 (3 H, m), 2.88 (2 H, t, *J* = 7.2 Hz), 2.56-2.51 (4 H, m), 2.31 (2 H, t, *J* = 8.1 Hz) and 2.15 (3 H, s) ppm.



14k

^{13}C NMR (100 MHz, $CDCl_3$): δ = 205.7, 178.2, 144.2, 136.0, 134.7, 133.3, 129.9, 129.3, 129.0, 127.9, 126.6, 126.2, 125.1, 124.0, 37.6, 31.6, 29.8, 29.6 and 20.9 ppm.

IR (neat): 3338, 3051, 2925, 2854, 1712 (C=O), 1695(C=O), 1600, 1507, 1427, 1241, 1215, 1144, 1017, 818 and 749 cm^{-1}.

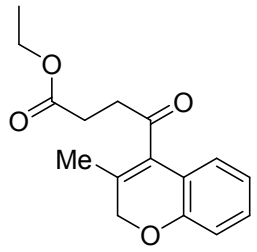
TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 139-141 °C

Ethyl 4-(3-methyl-2H-chromen-4-yl)-4-oxobutanoate (13l)

The hydroxyl-ester **12l** (50 mg, 0.18 mmol), and pTSA (17 mg, 0.09 mmol), in DCM (5 mL) were stirred for 20 h at 55 °C. Purification by flash column chromatography (8:1 hexanes:EtOAc) gave the 1,4-keto-ester **13l** (23 mg, 0.084 mmol, 45%) as a pale yellow oil.

^{1}H NMR (400 MHz, C_6D_6): δ = 7.16-7.14 (2 H, m), 7.02-6.97 (1 H, m), 6.92-6.89 (1 H, m), 4.31 (2 H, s), 4.16 (2 H, q, *J* = 7.1 Hz), 2.81 (2 H, t, *J* = 6.3 Hz), 2.65 (2 H, t, *J* = 6.3 Hz), 1.59 (3 H, s) and 1.18 (3 H, t, *J* = 7.1 Hz) ppm.



13l

^{13}C NMR (100 MHz, C_6D_6): δ = 203.8, 172.4, 153.4, 132.6, 129.8, 129.3, 129.0, 124.5, 122.0, 116.5, 68.8, 60.6, 38.5, 27.7, 15.8 and 14.2 ppm.

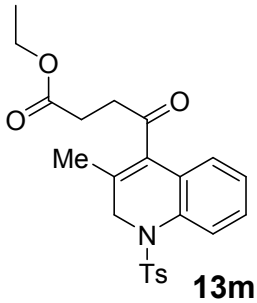
IR (neat): 2981, 2931, 2874, 2360, 2338, 1731 (OC=O), 1696 (C=O), 1606, 1542, 1457, 1373, 1353, 1301, 1212, 1177, 1071, 1032, 956 and 814 cm^{-1}.

HR ESI-MS:$[C_{16}H_{18}NaO_4]^+$ = $[M+Na]^+$ requires 297.1097; found 297.1101

TLC: R_f = 0.4 (8:1, Hex/EtOAc)

Ethyl 4-(3-methyl-1-tosyl-1,2-dihydroquinolin-4-yl)-4-oxobutanoate (13m)

The hydroxyl-ester **12m** (60 mg, 0.14 mmol), and pTSA (35 mg, 0.18 mmol), DCM (5 mL) were stirred for 15 h at 55 °C. Purification by flash



13m

column chromatography (5:1 hexanes:EtOAc) gave the 1,4-keto-ester **13m** (44 mg, 0.103 mmol, 73%) as a pale red oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.77 (1 H, d, *J* = 8.0 Hz), 7.62 (1 H, dd, *J* = 8.8 & 5.9 Hz), 7.08 (2 H, d, *J* = 8.3 Hz),7.24-7.21 (1 H, m), 7.19-7.17 (2 H, m), 6.87 (1 H, d, *J* = 6.8 Hz), 4.29 (2 H, s), 4.14 (2 H, q, *J* = 7.2 Hz), 2.45 (2 H, t, *J* = 6.4 Hz), 2.04 (2 H, t, *J* = 6.4 Hz), 1.69 (3 H, s) and 1.28 (3 H, t, *J* = 7.2 Hz) ppm.

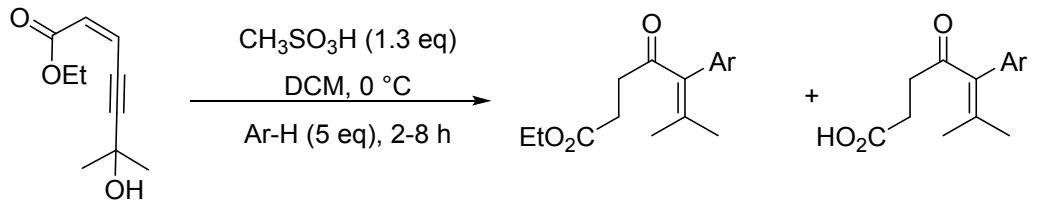
^{13}C NMR (100 MHz, $CDCl_3$): δ = 204.3, 172.4, 143.9, 136.5, 133.9, 131.7, 130.2, 129.6, 128.3, 127.8, 127.4, 127.2, 127.1, 124.2, 60.9, 49.8, 37.8, 27.5, 21.5, 18.2, and 14.3 ppm.

IR (neat): 2924, 2854, 2360, 2337, 1732 (OC=O), 1701 (C=O), 1597, 1488, 1452, 1351, 1185, 1088, 1036, 856 and 765 cm^{-1}.

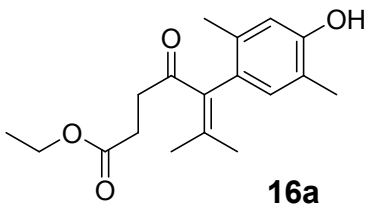
HR ESI-MS:$[C_{23}H_{25}NNaO_5S]^+$ = $[M+Na]^+$ requires 450.1346; found 450.1354

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

Synthesis of α-arylenones *via* developed intermolecular nucleophilic arylation strategy:



Ethyl 5-(4-hydroxy-2,5-dimethylphenyl)-6-methyl-4-oxohept-5-enoate (16a)



16a

The hydroxyl-ester[21] **15** (30 mg, 0.16 mmol), 2,5-dimethylphenol (100 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 6 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave 1,4-keto-ester **16a** (34 mg, 0.11 mmol, 70%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **17a** (5 mg, 1.018 mmol, 11%) as a colorless solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.80 (1 H, s), 6.65 (1 H, s), 5.43 (1 H, br s), 4.12 (2 H, q, *J* = 7.2 Hz), 2.54-2.43 (4 H, m), 2.19 (3 H, s), 2.10 (3 H, s), 2.06 (3 H, s), 1.56 (3 H, s) and 1.23 (3 H, t, *J* = 7.2 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.4, 173.5, 153.5, 146.2, 136.4, 135.8, 132.6, 130.4, 121.6, 116.7, 60.7, 37.2, 28.4, 23.9, 22.4, 19.4, 15.5 and 14.2 ppm.

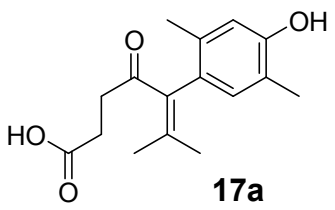
IR (neat): 3440, 2923, 2854, 2363, 2340, 1735 (OC=O), 1714 (C=O), 1677, 1613, 1594, 1507, 1458, 1402, 1375, 1227, 1153, 1032 and 854 cm^{-1}.

HR ESI-MS:$[C_{18}NaH_{24}O_4]^+$ = $[M+Na]^+$ requires 327.1567; found 327.1584

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

5-(4-Hydroxy-2,5-dimethylphenyl)-6-methyl-4-oxohept-5-enoic acid (17a)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.81 (1 H, s), 6.66 (1 H, s), 5.12 (1 H, br s), 2.54-2.37 (4 H, m), 2.21 (3 H, s), 2.12 (3 H, s), 2.06 (3 H, s) and 1.57 (3 H, s) ppm.



17a

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 177.5, 153.3, 147.2, 136.0, 135.9, 132.7, 130.6, 121.5, 116.7, 37.1, 29.8, 24.1, 22.5, 19.4 and 15.5 ppm.

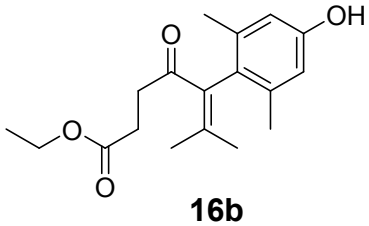
IR (neat): 3371, 2954, 2935, 2854, 1706 (C=O), 1688 (C=O), 1645, 1482, 1442, 1359, 1328, 1248, 1215, 1152, 1048, 897 and 730 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 132-134 °C

Ethyl 5-(4-hydroxy-2,6-dimethylphenyl)-6-methyl-4-oxohept-5-enoate (16b)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 3,5-dimethylphenol (100 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 6 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave 1,4-keto-ester **16b** (38 mg, 0.13 mmol, 78%) as a pale yellow oil.



16b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.59 (2 H, s), 5.71 (1 H, br s), 4.10 (2 H, q, *J* = 7.2 Hz), 2.48 (2 H, t, *J* = 6.5 Hz), 2.36 (2 H, t, *J* = 6.5 Hz), 2.20 (3 H, s), 2.07 (6 H, s), 1.52 (3 H, s) and 1.22 (3 H, t, *J* = 7.2 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.4 (C=O), 173.5 (O-C=O), 155.1, 148.8, 138.5, 134.4, 130.4, 114.8, 60.7, 36.6, 28.4, 23.9, 22.5, 20.3 and 14.3 ppm.

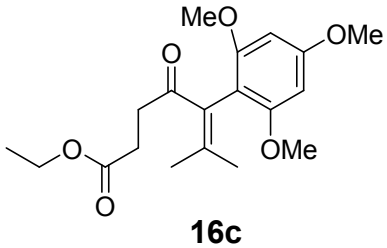
IR (neat): 3419, 2980, 2920, 2854, 1735 (OC=O), 1714 (C=O), 1675, 1607, 1592, 1460, 1374, 1347, 1207, 1149, 1028 and 852 cm^{-1}.

HR ESI-MS:$[C_{18}H_{25}O_4]^+ = [M+H]^+$ requires 305.1747; found 305.1749

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

Ethyl 6-methyl-4-oxo-5-(2,4,6-trimethoxyphenyl)hept-5-enoate (16c)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 1,3,5-trimethoxybenzene (138 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 6 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave the 1,4-keto-ester **16c** (42 mg, 0.12 mmol, 75%) as a pale yellow oil.



16c

^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.15 (2 H, s), 4.08 (2 H, q, *J* = 7.0 Hz), 3.84 (3 H, s), 3.75 (6 H, s), 2.45 (4 H, s), 2.14 (3 H, s), 1.56 (3 H, s) and 1.22 (3 H, t, *J* = 7.0 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 201.8, 173.5, 161.3, 158.8, 148.2, 128.4, 109.0, 90.6, 60.4, 55.8, 55.4, 36.2, 28.7, 24.3, 22.5 and 14.3 ppm.

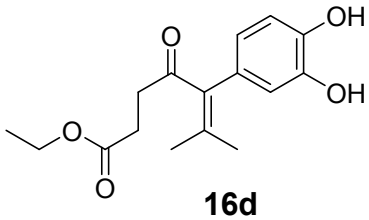
IR (neat): 2932, 2844, 2371, 1734 (OC=O), 1689 (C=O), 1605, 1585, 1495, 1462, 1414, 1371, 1336, 1205, 1153, 1061, 952 and 813 cm^{-1}.

HR ESI-MS:$[C_{19}H_{27}O_6]^+ = [M+H]^+$ requires 351.1802; found 351.1811

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

Ethyl 5-(3,4-dihydroxyphenyl)-6-methyl-4-oxohept-5-enoate (16d)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), catechol (82 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 6 h at 0 °C to RT. Purification by flash column chromatography (3:1 hexanes:EtOAc) gave 1,4-keto-ester **16d** (33 mg, 0.11 mmol, 71%) as a pale yellow oil.



16d

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.85 (1 H, d, *J* = 7.9 Hz), 6.77 (1 H, br s), 6.64 (1 H, s), 4.10 (2 H, q, *J* = 7.1 Hz), 2.62 (2 H, t, *J* = 6.2 Hz), 2.50 (2 H, t, *J* = 6.2 Hz), 1.99 (3 H, s), 1.65 (3 H, s), 1.65 (3 H, s) and 1.23 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 204.3, 173.9, 144.1, 143.9, 143.7, 137.6, 130.7, 122.5, 116.6, 115.5, 61.1, 37.4, 28.5, 23.6, 22.5 and 14.2 ppm.

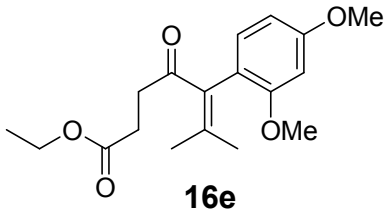
IR (neat): 3444, 2980, 2921, 2853, 1734 (OC=O), 1689 (C=O), 1598, 1456, 1426, 1372, 1344, 1261, 1205, 1178, 1150, 1014 and 764 cm^{-1}.

HR ESI-MS:$[C_{16}H_{21}O_5]^+ = [M+H]^+$ requires 293.1384; found 293.1389

TLC: R_f = 0.4 (3:1, Hex/EtOAc)

Ethyl 5-(2,4-dimethoxyphenyl)-6-methyl-4-oxohept-5-enoate (16e)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 1,3-dimethoxybenzene (113 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 4 h at 0 °C to RT. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave the 1,4-keto-ester **16e** (35 mg, 0.11 mmol, 68%) as a pale yellow oil.



16e

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.01 (1 H, d, *J* = 8.0 Hz), 6.51-6.47 (2 H, m), 4.11 (2 H, q, *J* = 7.1 Hz), 3.83 (3 H, s), 3.75 (3 H, s), 2.51-2.45 (4 H, m), 2.90 (3 H, s), 1.64 (3 H, s) and 1.23 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.3, 173.3, 160.8, 158.3, 145.9, 133.7, 132.4, 120.4, 104.6, 98.8, 60.5, 55.6, 55.5, 36.7, 28.6, 24.2, 22.6 and 14.3 ppm.

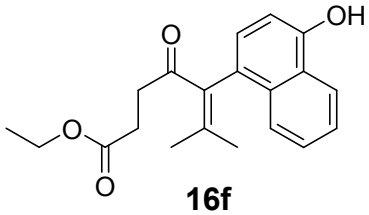
IR (neat): 2923, 2851, 2364, 2340, 1735 (OC=O), 1684 (C=O), 1608, 1578, 1504, 1443, 1372, 1302, 1272, 1155, 1114, 1033 and 800 cm^{-1}.

HR ESI-MS:$[C_{18}NaH_{24}O_5]^+ = [M+Na]^+$ requires 343.1516; found 343.1509

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

Ethyl 5-(4-hydroxynaphthalen-1-yl)-6-methyl-4-oxohept-5-enoate (16f)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), Naphthalen-1-ol (115 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 8 h at 0 °C to



16f

RT. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave 1,4-keto-ester **16f** (41 mg, 0.13 mmol, 79%) as a red color oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 8.31-8.23 (1 H, m), 7.75-7.73 (1 H, m), 7.48-7.45 (2 H, m), 7.11 (1 H, d, *J* = 7.5 Hz), 6.81 (1 H, dd, *J* = 7.6 & 3.6 Hz), 4.10 (2 H, q, *J* = 7.1 Hz), 2.65-2.58 (1 H, m), 2.53-2.34 (3 H, m), 2.25 (3 H, s), 1.54 (3 H, s) and 1.20 (3 H, t, *J* = 7.1 Hz) ppm.

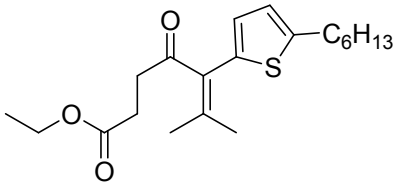
^{13}C NMR (125 MHz, $CDCl_3$): δ = 203.1, 173.9, 152.2, 148.1, 135.5, 133.4, 128.1, 127.1, 125.2, 125.1, 122.7, 108.4, 60.9, 36.9, 28.5, 24.3, 22.7 and 14.2 ppm.

IR (neat): 3397, 2982, 2919, 2363, 2340, 1733 (OC=O), 1706 (C=O), 1671, 1586, 1513, 1372, 1237, 1151, 1047, 1024, 1004 and 767 cm^{-1}.

HR ESI-MS:$[C_{20}H_{22}NaO_4]^+$ = $[M+Na]^+$ requires 349.1410; found 349.1410

TLC: R_f = 0.4 (4:1, Hex/EtOAc).

Ethyl 5-(5-hexylthiophen-2-yl)-6-methyl-4-oxohept-5-enoate (16g)



16g

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 2-hexylthiophene (134.4 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 3 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **16g** (35 mg, 0.1 mmol, 63%) as a pale red oil. Further elution with 3:2 hex-EA mixture afforded the keto-acid **17a** (16 mg, 0.05 mmol, 31%) as a pale yellow oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.67 (1 H, d, *J* = 3.4 Hz), 6.61 (1 H, d, *J* = 3.4 Hz), 4.11 (2 H, q, *J* = 7.1 Hz), 2.78 (2 H, t, *J* = 7.6 Hz), 2.73 (2 H, t, *J* = 6.5 Hz), 2.52 (2 H, d, *J* = 6.5 Hz), 2.02 (3 H, s), 1.82 (3 H, s), 1.69-1.63 (2 H, m), 1.37-1.34 (2 H, m), 1.33-1.28 (4 H, m), 1.23 (3 H, t, *J* = 7.1 Hz) and 0.88 (3 H, t, *J* = 6.6 Hz) ppm.

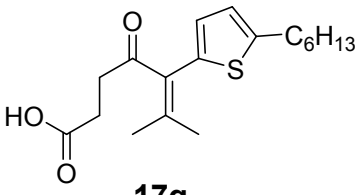
^{13}C NMR (125 MHz, $CDCl_3$): δ = 202.5, 173.1, 147.1, 145.59, 136.2, 131.3, 127.5, 124.1, 60.6, 37.1, 31.7, 31.6, 30.3, 28.9, 28.4, 23.8, 22.7, 22.6, 14.3 and 14.2 ppm.

IR (neat): 2957, 2927, 2855, 2368, 1737 (OC=O), 1688 (C=O), 1600, 1459, 1443, 1372, 1345, 1204, 1174, 1148, 1034, 1014 and 802 cm^{-1}.

HR ESI-MS:$[C_{20}H_{31}O_3S]^+ = [M+H]^+$ requires 351.1988; found 351.1995

TLC: $R_f = 0.4$ (9:1, Hex/EtOAc)

5-(5-Hexylthiophen-2-yl)-6-methyl-4-oxohept-5-enoic acid (17g)



17g

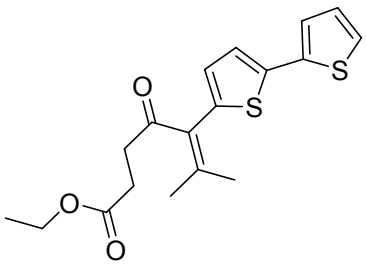
^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.68 (1 H, d, *J* = 3.5 Hz), 6.61 (1 H, d, *J* = 3.5 Hz), 2.78 (2 H, t, *J* = 7.8 Hz), 2.72 (2 H, t, *J* = 6.5 Hz), 2.57 (2 H, d, *J* = 6.5 Hz), 2.03 (3 H, s), 1.82 (3 H, s), 1.69-1.64 (2 H, m), 1.38-1.35 (2 H, m), 1.33-1.29 (4 H, m) and 0.88 (3 H, t, *J* = 6.6 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 178.6, 147.2, 147.1, 136.2, 131.0, 127.6, 124.1, 36.8, 31.7, 31.6, 30.3, 28.9, 28.3, 24.0, 22.8, 22.7 and 14.2 ppm.

IR (neat): 3381, 2964, 2945, 2856, 1710 (C=O), 1695 (C=O), 1655, 1492, 1446, 1357, 1329, 1278, 1235, 1142, 1058, 887 and 739 cm^{-1}.

TLC: $R_f = 0.4$ (2:1, Hex/EtOAc).

Ethyl 5-(2,2'-bithiophen-5-yl)-6-methyl-4-oxohept-5-enoate (16h)



16h

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 2,2'-bithiophene (133 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 4.5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **16h** (45 mg, 0.13 mmol, 81%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **17h** (7.5 mg, 0.02 mmol, 15%) as a color less solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21 (1 H, d, *J* = 5.2 Hz), 7.16-7.14 (1 H, m), 7.09 (1 H, d, *J* = 3.10 Hz), 7.01-6.99 (1 H, m), 6.74 (1 H, d, *J* = 3.6 Hz), 4.12 (2 H, q, *J* = 7.1 Hz), 2.78 (2 H, t, *J* = 6.5 Hz), 2.55 (2 H, t, *J* = 6.5 Hz), 2.05 (3 H, s), 1.88 (3 H, s) and 1.24 (3 H, t, *J* = 7.1 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 172.9, 147.2, 138.3, 137.9, 137.2, 130.5, 128.7, 127.9, 124.4, 123.8, 123.7, 60.6, 37.1, 28.4, 23.9, 22.8 and 14.3 ppm.

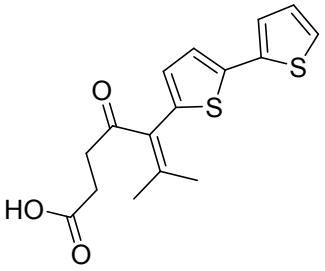
IR (neat): 2982, 2919, 2364, 2340, 1733 (OC=O), 1706 (C=O), 1671, 1586, 1513, 1372, 1344, 1215, 1151, 1024, 1004 and 826 cm^{-1}.

HR ESI-MS:$[C_{18}H_{21}O_3S_2]^+$ = $[M+H]^+$ requires 349.0927; found 349.0925

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

5-(2,2'-Bithiophen-5-yl)-6-methyl-4-oxohept-5-enoic acid (17h)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22 (1 H, dd, *J* = 5.2 & 1.1Hz), 7.16 (1 H, dd, J = 4.0 & 1.1 Hz), 7.10 (1 H, d, *J* = 3.9 Hz), 7.01 (1 H, dd, J = 5.1 & 4.0 Hz), 6.74 (1 H, d, *J* = 3.7 Hz), 2.78 (2 H, t, *J* = 6.6 Hz), 2.59 (2 H, t, *J* = 6.6 Hz), 2.07 (3 H, s) and 1.88 (3 H, s) ppm



17h

^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.5, 178.5, 148.4, 138.4, 137.9, 137.2, 130.2, 128.8, 127.9, 124.6, 123.9, 123.8, 36.9, 28.2, 24.2 and 22.9 ppm.

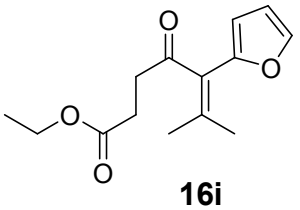
IR (neat): 3383, 2944, 2925, 2855, 1710 (C=O), 1695 (C=O), 1644, 1472, 1432, 1379, 1358, 1258, 1216, 1172, 1058, 951, 895 and 737 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

M.P.: 111 -113 °C

Ethyl 5-(furan-2-yl)-6-methyl-4-oxohept-5-enoate (16i)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), furan (54 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 2.5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the 1,4-keto-ester **16i** (28 mg, 0.11 mmol, 70%) as a pale yellow oil.



16i

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.42 (1 H, d, *J* = 1.3 Hz), 6.42 (1 H, dd, *J* = 3.0 & 1.6 Hz), 6.26 (1 H, d, *J* = 3.2 Hz), 4.12 (2 H, q, *J* = 7.1 Hz), 2.68 (2 H, t, *J* = 6.6 Hz), 2.56 (2 H, t, *J* = 6.6 Hz), 2.02 (3 H, s), 1.89 (3 H, s) and 1.24 (3 H, t, *J* = 7.1 Hz) ppm.

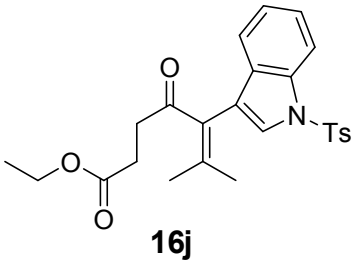
^{13}C NMR (125 MHz, $CDCl_3$): δ = 202.0, 173.0, 150.4, 146.2, 142.1, 128.9, 111.0, 110.3, 60.7, 37.3, 28.4, 23.7, 22.8 and 14.3 ppm.

IR (neat): 2979, 2922, 2853, 2368, 2327, 1734 (OC=O), 1703 (C=O), 1458, 1417, 1394, 1374, 1347, 1198, 1153, 1018 and 737 cm^{-1}.

HR ESI-MS:$[C_{14}H_{19}O_4]^+ = [M+H]^+$ requires 251.1278; found 251.1282

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

Ethyl 6-methyl-4-oxo-5-(1-tosyl-1H-indol-3-yl)hept-5-enoate (16j)



16j

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 1-tosyl-1H-indole (222 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 3 h at 0 °C to RT. Purification by flash column chromatography (8:1 hexanes:EtOAc) gave 1,4-keto-ester **16j** (49 mg, 0.11 mmol, 68%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **17j** (9 mg, 0.021 mmol, 13%) as a pale yellow semi solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.01 (1 H, d, *J* = 8.4 Hz), 7.76 (2 H, d, *J* = 8.4 Hz), 7.45 (1 H, s), 7.36-7.31 (2 H, m), 7.26-7.20 (3 H, m), 4.09 (2 H, q, *J* = 7.2 Hz), 2.48-2.40 (4 H, m), 2.34 (3 H, s), 2.14 (3 H, s), 1.63 (3 H, s) and 1.22 (3 H, t, *J* = 7.2 Hz) ppm.

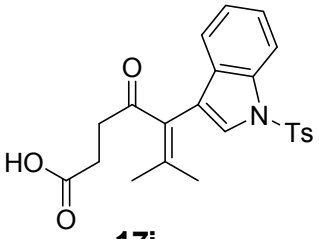
^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.6, 172.9, 149.0, 145.2, 135.2, 130.8, 130.0, 127.8, 126.9, 125.4, 125.3, 123.9, 120.4, 120.3, 114.1, 60.6, 36.7, 28.4, 24.2, 22.7, 21.7 and 14.3 ppm.

IR (neat): 2980, 2923, 2854, 1733 (OC=O), 1685 (C=O), 1598, 1445, 1401, 1371, 1302, 1208, 1175, 1124, 1089, 1018, 983 and 766 cm^{-1}.

HR ESI-MS:$[C_{25}H_{27}NO_5SNa]^+ = [M+Na]^+$ requires 476.1502; found 476.1502

TLC: R_f = 0.4 (8:1, Hex/EtOAc)

Ethyl 6-methyl-4-oxo-5-(1-tosyl-1H-indol-3-yl)hept-5-enoate (17j)



17j

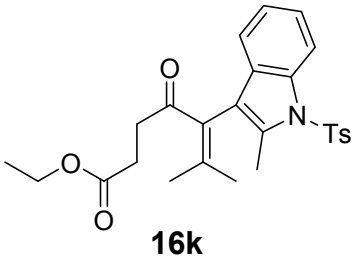
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.02 (1 H, d, *J* = 8.4 Hz), 7.75 (2 H, d, *J* = 8.4 Hz), 7.44 (1 H, s), 7.37-7.29 (2 H, m), 7.26-7.19 (3 H, m), 2.49-2.42 (4 H, m), 2.32 (3 H, s), 2.15 (3 H, s), and 1.64 (3 H, s) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.6, 177.6, 149.1, 149.1, 145.2, 135.2, 130.8, 130.0, 126.9, 125.4, 125.3, 123.9, 120.4, 120.3, 114.1, 36.7, 28.3, 24.2, 22.7 and 21.7 ppm.

IR (neat): 3371, 2954, 2935, 2854, 1716 (C=O), 1692 (C=O), 1645, 1482, 1442, 1379, 1328, 1248, 1215, 1162, 1078, 897 and 771 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

Ethyl 6-methyl-5-(2-methyl-1-tosyl-1H-indol-3-yl)-4-oxohept-5-enoate (16k)



16k

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 2-methyl-*N*-tosyl-indole (234 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 3.5 h at 0 °C to RT. Purification by flash column chromatography (8:1 hexanes:EtOAc) gave 1,4-keto-ester **16k** (49 mg, 0.11 mmol, 66%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixtures afforded the keto-acid **17k** (14 mg, 0.032 mmol, 19%) as a pale yellow semi solid.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.21 (1 H, d, *J* = 8.3 Hz), 7.62 (2 H, d, *J* = 8.3 Hz), 7.32-7.28 (1 H, m), 7.25-7.17 (4 H, m), 4.02 (2 H, q, *J* = 7.1 Hz), 2.46 (3 H, s), 2.43-2.22 (7 H, m), 2.17 (3 H, s), 1.49 (3 H, s) and 1.21 (3 H, t, *J* = 7.1 Hz) ppm.

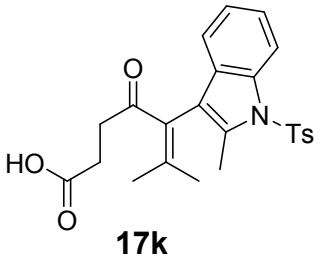
^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.1, 172.9, 150.6, 145.0, 136.7, 136.2, 135.1, 130.2, 130.0, 127.7, 126.4, 124.6, 124.1, 119.8, 119.2, 115.1, 60.6, 36.5, 28.3, 24.0, 22.6, 21.7, 14.3 and 13.6 ppm.

IR (neat): 2924, 2854, 1735 (OC=O), 1684 (C=O), 1619, 1595, 1453, 1373, 1237, 1175, 1090, 1019 and 750 cm^{-1}.

HR ESI-MS:$[C_{26}\ H_{29}NNaO_5S]^+$ = $[M+Na]^+$ requires 490.1659; found 490.1653

TLC: R_f = 0.4 (8:1, Hex/EtOAc)

6-Methyl-5-(2-methyl-1-tosyl-1H-indol-3-yl)-4-oxohept-5-enoic acid (17k)



17k

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.21 (1 H, d, *J* = 8.3 Hz), 7.62 (2 H, d, *J* = 8.3 Hz), 7.33-7.29 (1 H, m), 7.25-7.17 (4 H, m), 2.44 (3 H, s), 2.41-2.21 (7 H, m), 2.18 (3 H, s) and 1.51 (3 H, s) ppm.

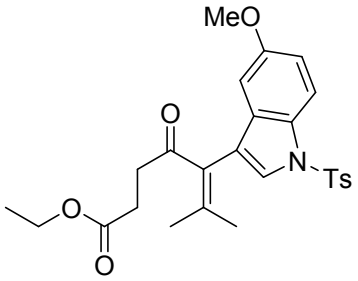
^{13}C NMR (100 MHz, $CDCl_3$): δ = 200.8, 178.0, 151.5, 145.0, 136.8, 136.2, 135.1, 130.1, 129.9, 127.5, 126.4, 124.7, 124.1, 119.8, 119.2, 115.1, 36.2, 28.0, 24.2, 22.6, 21.7 and 13.6 ppm.

IR (neat): 3442, 2951, 2936, 2855, 1710 (C=O), 1699 (C=O), 1645, 1483, 1442, 1392, 1353, 1314, 1262, 1245, 1154, 1026, 948 and 813 cm^{-1}.

TLC: R_f = 0.4 (2:1, Hex/EtOAc).

Ethyl 5-(5-methoxy-1-tosyl-1H-indol-3-yl)-6-methyl-4-oxohept-5-enoate (16i)

The hydroxyl-ester **15** (30 mg, 0.16 mmol), 5-methoxy-1-tosyl-1H-indole (247 mg, 0.82 mmol), in DCM (3 mL), and MsOH (19.2 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 38 h at 0 °C to RT. Purification by flash column chromatography (8:1 hexanes:EtOAc) gave 1,4-keto-ester **16l** (52 mg, 0.11 mmol, 68%) as a pale yellow color oil.



16l

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.90 (1 H, d, *J* = 9.1 Hz), 7.72 (2 H, d, *J* = 8.3 Hz), 7.39 (1 H, m), 7.19 (2 H, d, *J* = 8.3 Hz), 6.94 (1 H, dd, *J* = 9.1 & 2.4 Hz), 6.72 (1 H, d, *J* = 2.3 Hz), 4.09 (2 H, q, *J* = 7.2 Hz), 3.78 (3 H, s), 2.47-2.39 (4 H, m), 2.33 (3 H, s), 2.14 (3 H, s), 1.63 (3 H, s) and 1.22 (3 H, t, *J* = 7.2 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.5, 172.9, 157.1, 149.3, 145.1, 135.2, 132.0, 130.0, 129.9, 127.8, 126.8, 126.3, 120.7, 115.1, 114.4, 102.4, 60.6, 55.8, 36.7, 28.3, 24.3, 22.7, 21.7 and 14.3 ppm.

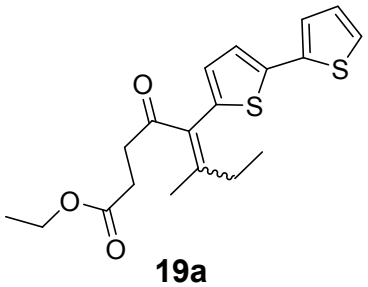
IR (neat): 2957, 2922, 2853, 1734 (OC=O), 1684 (C=O), 1602, 1473, 1370, 1264, 1216, 1173, 1121, 1088, 1031, 983 and 727 cm^{-1}.

HR ESI-MS:[$C_{26}H_{29}NNaO_6S]^+$ = $[M+Na]^+$ requires 506.1608; found 506.1609

TLC: R_f = 0.4 (8:1, Hex/EtOAc)

Ethyl 5-(2,2'-bithiophen-5-yl)-6-methyl-4-oxooct-5-enoate (19a)

The hydroxyl-ester[21] **18a** (30 mg, 0.153 mmol), 2,2'-bithiophene (141 mg, 0.85 mmol), in DCM (3 mL), and MsOH (19.5 mg, 0.02 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 5.5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19a** (39 mg, 0.108 mmol, 71%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **20a** (11 mg, 0.02 mmol, 20%) as a pale red semi solid.



19a

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21 (1.5 H, d, *J* = 5.1 Hz), 7.16-7.15 (1.5 H, m), 7.10 (1.4 H, d, *J* = 3.6 Hz), 7.02-7.00 (1.5 H, m), 6.74 (1.4 H, d, *J* = 3.6 Hz), 4.12 (3.2 H, q, *J* = 7.2 Hz), 2.81-2.75 (3.1 H, m), 2.57-2.52 (3.1 H, m), 2.34 (2 H, q, *J* = 7.5 Hz), 2.18 (1 H, q, *J* = 7.5 Hz), 2.05 (1.6 H, s), 1.88 (3 H, s), 1.24 (4.5 H, t, *J* = 7.1 Hz), 1.14 (3 H, t, *J* = 7.5 Hz) and 1.06 (1.6 H, t, *J* = 7.5 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 201.9, 173.0, 172.9, 153.2, 151.1, 138.3, 138.2, 137.8, 137.7, 137.2, 130.4, 129.6, 128.6, 128.0, 124.6, 123.8, 60.7, 37.3, 37.2, 30.2, 29.8, 29.3, 28.4, 20.9, 20.0, 14.3, 13.2 and 13.0 ppm.

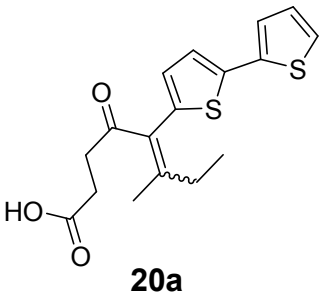
IR (neat): 2984, 2910, 2354, 2310, 1735 (OC=O), 1698 (C=O), 1654, 1519, 1501, 1368, 1322, 1211, 1111, 1002 and 850 cm^{-1}.

HR ESI-MS:[$C_{19}NaH_{22}O_3S_2]^+$ = $[M+Na]^+$ requires 385.0903; found 385.0889

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

5-(2,2'-Bithiophen-5-yl)-6-methyl-4-oxooct-5-enoic acid (20a)

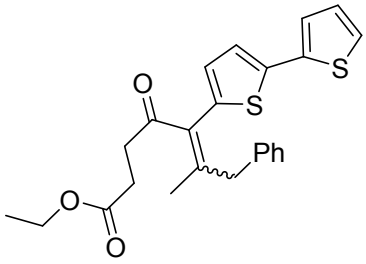
^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22-7.19 (1 H, m), 7.18-7.16 (1 H, m), 7.10-7.08 (1 H, m), 7.02-7.00 (1 H, m), 6.77 (1 H, d, *J* = 3.6 Hz), 2.78-2.75 (2.3 H, m), 2.61-2.58 (2.4 H, m), 2.36 (1 H, q, *J* = 7.02 Hz), 2.18 (1.6 H, q, *J* = 7.02 Hz), 2.06 (2.3 H, s), 1.87 (1.6 H, s), 1.14 (1.5 H, t, *J* = 7.3 Hz) and 1.06 (2.4 H, t, *J* = 7.3 Hz) ppm**.**



20a

Ethyl 5-(2,2'-bithiophen-5-yl)-6-methyl-4-oxo-7-phenylhept-5-enoate (19b)

The hydroxyl-ester **18b** (30 mg, 0.12 mmol), 2,2'-bithiophene (99.6 mg, 0.6 mmol), in DCM (3 mL), and MsOH (15.2 mg, 0.16 mmol, 0.11 ml of 1.4 *M* in DCM) were stirred for 5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19b** (38 mg, 0.09 mmol, 74%) as a pale yellow oil. Further elution with 3:2 hexanes-EA mixture afforded the keto-acid **20b** (10 mg, 0.03 mmol, 20%) as a pale red semi solid.



19b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.32-7.27 (4.6 H, m), 7.23-7.20 (2.6 H, m), 7.16-7.14 (1.9 H, m), 7.12 (1 H, d, *J* = 3.8 Hz), 7.09 (0.4 H, d, *J* = 3.8 Hz), 7.02-6.99 (1.3 H, m), 6.84 (0.3 H, d, *J* = 3.7 Hz), 6.80 (1 H, d, *J* = 3.7 Hz), 4.11 (2.7 H, q, *J* = 7.1 Hz), 3.67 (2 H, s), 3.56 (0.4 H, s), 2.87 (2.5 H, t, *J* = 6.4 Hz), 2.58 (2.5 H, t, *J* = 6.4 Hz), 1.92 (0.6 H, s), 1.78 (3 H, s) and 1.22 (4.12 H, t, *J* = 7.1 Hz) ppm.

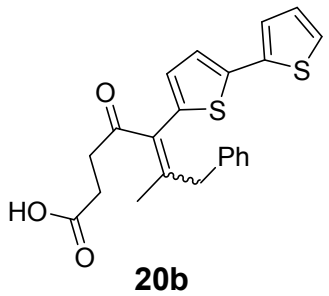
^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.4, 172.8, 147.7, 146.1, 138.8, 138.6, 137.2, 137.1, 132.4, 129.2, 129.0, 128.9, 128.7, 128.6, 128.0, 126.6, 126.5, 124.7, 124.0, 123.9, 123.8, 60.7, 42.3, 41.5, 37.4, 37.3, 28.3, 20.8, 20.3, 14.3 and 14.2 ppm.

IR (neat): 2985, 2911, 2354, 2312, 1734 (OC=O), 1701 (C=O), 1664, 1591, 1515, 1375, 1342, 1211, 1115, 1022, 1011 and 822 cm^{-1}.

HR ESI-MS:[$C_{24}NaH_{24}O_3S_2]^+$ = $[M+Na]^+$ requires 447.1059; found 447.1071

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

5-(2,2'-Bithiophen-5-yl)-6-methyl-4-oxo-7-phenylhept-5-enoic acid (20b)

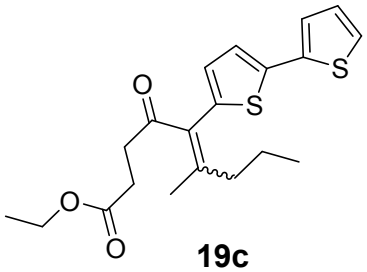


20b

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.33-7.27 (3 H, m), 7.24-7.20 (2 H, m), 7.17-7.13 (2 H, m), 7.11-7.09 (1 H, m), 7.02-6.99 (1 H, m), 6.84 (0.5 H, d, *J* = 3.6 Hz), 6.79 (0.5 H, d, *J* = 3.6 Hz), 3.69 (1 H, s), 3.56 (1 H, s), 2.87-2.83 (2 H, m), 2.64-2.61 (2 H, m), 1.92 (1.3 H, s) and 1.79 (1.7 H, s) ppm

Ethyl 5-(2,2'-bithiophen-5-yl)-6-methyl-4-oxonon-5-enoate (19c)

The hydroxyl-ester[21] **18c** (50 mg, 0.24 mmol), 2,2'-bithiophene (199 mg, 1.2 mmol), in DCM (5 mL), and MsOH (29.7 mg, 0.31 mmol, 0.22 ml of 1.4 *M* in DCM) were stirred for 5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19c** (74 mg, 0.2 mmol, 82%) as a pale yellow oil.



19c

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.21 (1 H, d, *J* = 5.1 Hz), 7.15 (1 H, d, *J* = 2.8 Hz), 7.08 (1 H, d, *J* = 3.9 Hz), 7.01 (1 H, d, *J* = 5.1 Hz), 6.73 (1 H, d, *J* = 3.3 Hz), 4.11 (2 H, q, *J* = 7.1 Hz), 2.81-2.76 (2 H, m), 2.56-2.52 (2 H, m), 2.31 (1.3 H, d, *J* = 7.8 Hz), 2.14 (0.8 H, d, *J* = 7.8 Hz), 2.03 (1.3 H, s), 1.87 (1.8 H, s), 1.58-1.46 (2 H, s), 1.24 (3 H, t, *J* = 7.1 Hz), 0.96 (1.5 H, t, *J* = 7.4 Hz) and 0.87 (1.8 H, t, *J* = 7.4 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.1, 202.0, 173.0, 172.9, 151.6, 149.5, 139.4, 138.3, 137.8, 137.7, 137.2, 131.0, 130.1, 128.7, 128.6, 127.9, 124.6, 123.8, 114.2, 60.9, 60.7, 39.0, 38.0, 37.4, 34.4, 33.9, 32.0, 31.7, 29.8, 28.4, 22.8, 21.9, 21.6, 21.3, 20.4, 14.3, 14.2 and 14.1 ppm.

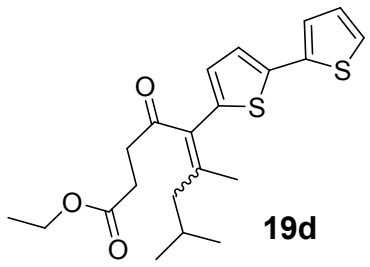
IR (neat): 2960, 2925, 2853, 1734 (OC=O), 1688 (C=O), 1464, 1375, 1346, 1265, 1203, 1163, 1080, 1022, 839, 802 and 739 cm^{-1}.

HR ESI-MS:$[C_{20}H_{24}NaO_3S_2]^+$ = $[M+Na]^+$ requires 399.1059; found 399.1063

TLC: R_f = 0.4 (9:1, Hex/EtOAc).

Ethyl 5-(2,2'-bithiophen-5-yl)-6,8-dimethyl-4-oxonon-5-enoate (19d)

The hydroxyl-ester[21] **18d** (50 mg, 0.22 mmol), 2,2'-bithiophene (185 mg, 1.12 mmol), in DCM (5 mL), and MsOH (27.4 mg, 0.29 mmol, 0.2 ml of 1.4 *M* in DCM) were stirred for 2 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19d** (67 mg, 0.17 mmol, 78%) as a pale yellow oil.



^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.22 (1 H, d, *J* = 5.1 Hz), 7.16 (1 H, d, *J* = 3.1 Hz), 7.09 (1 H, d, *J* = 3.2 Hz), 6.73 (1 H, d, *J* = 3.6 Hz), 4.11 (0.4 H, q, *J* = 7.1 Hz), 4.11 (1.6 H, q, *J* = 7.1 Hz), 2.27 (1.6 H, d, *J* = 7.5 Hz), 2.10 (0.4 H, d, *J* = 7.5 Hz), 2.02 (0.5 H, s), 1.87 (2.5 H, s), 1.24 (3 H, t, *J* = 7.1 Hz), 0.92 (5.4 H, d, *J* = 6.7 Hz) and 0.89-0.83 (2.3 H, m) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.4, 201.9, 173.0172.8, 147.9, 138.3, 137.7, 137.2, 132.0, 129.1, 128.6, 127.9, 124.6, 123.8, 60.9, 60.6, 45.5, 44.3, 41.3, 37.6, 37.1, 31.8, 29.8, 28.3, 27.3, 22.5, 22.3, 21.2, 20.5, 15.8 and 14.3 ppm.

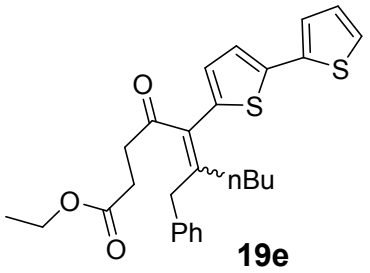
IR (neat): 2957, 2927, 2869, 1735 (OC=O), 1688 (C=O), 1593, 1463, 1373, 1345, 1255, 1204, 1165, 1086, 1023, 857 and 802 cm^{-1}.

HR ESI-MS:$[C_{21}H_{26}NaO_3S_2]^+$ = $[M+Na]^+$ requires 413.1216; found 413.1216

TLC: R_f = 0.4 (9:1, Hex/EtOAc).

Ethyl 5-(2,2'-bithiophen-5-yl)-6-benzyl-4-oxodec-5-enoate (19e)

The hydroxyl-ester **18e** (45 mg, 0.15 mmol), 2,2'-bithiophene (125 mg, 0.75 mmol), in DCM (4 mL), and MsOH (18.7 mg, 0.19 mmol, 0.14 ml of 1.4 *M* in DCM) were stirred for 2.5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19e** (49 mg, 0.11 mmol, 70%) as a pale yellow oil.



^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31-7.28 (3 H, m), 7.23-7.20 (2 H, m), 7.18-7.13 (2 H, m), 7.11 (0.7 H, d, *J* = 3.5 Hz), 7.07 (0.3 H, d, *J* = 3.5 Hz), 7.02 (0.7 H, dd, *J* = 5.2 & 3.7 Hz), 6.99 (0.3 H, dd, *J* = 5.2 & 3.7 Hz), 6.82 (0.3 H, d, *J* = 3.7 Hz), 6.81 (0.7 H, d, *J* = 3.7 Hz), 4.15-4.08

(2 H, m), 3.69 (1.4 H, s), 3.61 (0.5 Hz), 2.89 (0.5 H, t, *J* = 6.6 Hz), 2.84 (1.5 H, t, *J* = 6.6 Hz), 2.59-2.53 (2 H, m), 2.21 (0.6 H, t, *J* = 8.1 Hz), 2.09 (1.4 H, t, *J* = 8.1 Hz), 1.47-1.39 (2 H, m), 1.25-1.21 (3 H, m), 0.87 (0.9 H, t, *J* = 7.3 Hz) and 0.82 (2.1 H, t, *J* = 7.3 Hz) ppm.

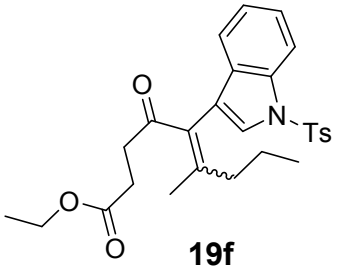
^{13}C NMR (100 MHz, $CDCl_3$): δ = 202.6, 202.3, 173.0, 172.9, 150.6, 150.4, 139.0, 138.5, 137.2, 137.1, 136.8, 132.2, 129.2, 128.9, 128.7, 128.6, 128.0, 126.5, 126.4, 124.7, 124.0, 123.9, 123.8, 60.7, 39.1, 38.4, 37.5, 37.4, 32.7, 32.6, 31.3, 30.9, 29.8, 28.4, 28.3, 23.0, 22.9, 14.3, 14.0 and 13.9 ppm.

IR (neat): 2956, 2925, 2855, 1734 (OC=O), 1688 (C=O), 1599, 1494, 1455, 1423, 1374, 1260, 1205, 1119, 1031, 838 and 736 cm^{-1}.

HR ESI-MS:$[C_{27}H_{30}NaO_3S_2]^+$ = $[M+Na]^+$ requires 489.1529; found 489.1535

TLC: R_f = 0.4 (9:1, Hex/EtOAc).

Ethyl 6-methyl-4-oxo-5-(1-tosyl-1H-indol-3-yl)non-5-enoate (19f)



19f

The hydroxyl-ester[21] **18f** (50 mg, 0.24 mmol), 1-tosyl-1H-indole (325 mg, 1.2 mmol), in DCM (5 mL), and MsOH (29.7 mg, 0.31 mmol, 0.22 ml of 1.4 *M* in DCM) were stirred for 2.5 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19f** (84 mg, 0.17 mmol, 73%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.02 (1 H, d, *J* = 8.7 Hz), 7.75 (2 H, m), 7.45 (0.5 H, s), 7.42 (0.5 H, s), 7.34-7.31 (2 H, m), 7.26-7.20 (3 H, m), 4.08 (2 H, q, *J* = 7.1 Hz), 2.47-2.41 (4 H, m), 2.33 (3 H, s), 2.12 (1.5 H, s), 1.83 (1 H, t, *J* = 7.7 Hz), 1.62-1.57 (2.7 H, m), 1.21 (3 H, t, *J* = 7.1 Hz), 1.04-0.97 (2 H, m), 0.87 (1.6 H, t, *J* = 7.4 Hz) and 0.65 (1.5 H, t, *J* = 7.4 Hz) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 201.6, 201.5, 172.9, 172.8, 153.2, 152.0, 145.2, 135.3, 135.2, 131.1, 130.7, 130.0, 128.2, 127.5, 126.9, 126.8, 125.5, 125.4, 125.3, 125.2, 123.9, 123.8, 120.4, 114.1, 60.6, 39.4, 37.6, 36.9, 36.8, 29.8, 28.3, 22.1, 21.7, 21.6, 21.5, 20.8, 20.4, 14.3 and 14.1 ppm.

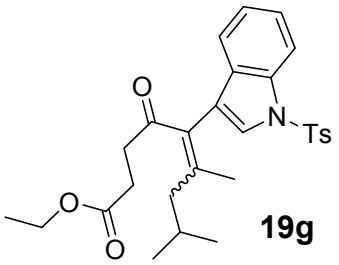
IR (neat): 2960, 2926, 2870, 2360, 1734 (OC=O), 1687 (C=O), 1599, 1554, 1446, 1373, 1305, 1203, 1183, 1124, 1019, 813 and 764 cm^{-1}.

HR ESI-MS:$[C_{27}H_{31}NNaO_5S]^+$ = $[M+Na]^+$ requires 504.1815; found 504.1823

TLC: R_f = 0.4 (4:1, Hex/EtOAc).

Ethyl 6,8-dimethyl-4-oxo-5-(1-tosyl-1H-indol-3-yl)non-5-enoate (19g)

The hydroxyl-ester[21] **18g** (50 mg, 0.22 mmol), 1-tosyl-1H-indole (303 mg, 1.12 mmol), in DCM (5 mL), and MsOH (27.4 mg, 0.28 mmol, 0.22 ml of 1.4 *M* in DCM) were stirred for 3 h at 0 °C to RT. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave 1,4-keto-ester **19g** (78 mg, 0.16 mmol, 71%) as a pale yellow oil



19g

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.01 (1 H, d, *J* = 7.0 Hz), 7.76 (1 H, d, *J* = 7.2 Hz), 7.45 (1 H, s), 7.35-7.30 (2 H, m), 7.24-7.19 (3 H, m), 4.20 (0.4 H, q, *J* = 7.1 Hz), 4.03 (1.6 H, q, *J* = 7.1 Hz), 2.51-2.48 (1 H, m), 2.42-2.39 (3 H, m), 2.33 (3 H, s), 1.67-1.53 (5 H, m), 1.21 (3 H, t, *J* = 7.1 Hz), 1.04-0.92 (6 H, m) and 0.89-0.86 (1 H, m) ppm.

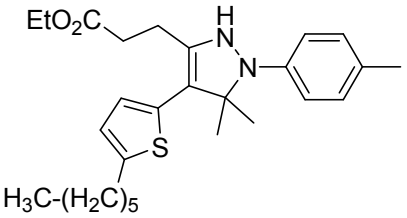
^{13}C NMR (100 MHz, $CDCl_3$): δ = 201.9, 172.8, 150.3, 145.2, 135.2, 130.7, 130.0, 129.9, 129.3, 126.9, 125.3, 125.2, 123.9, 120.4, 114.1, 60.6, 43.8, 37.1, 29.8, 28.3, 27.4, 22.8, 22.6, 22.4, 21.7, 21.5, 14.3 and 14.2 ppm.

IR (neat): 2957, 2925, 269, 1734 (OC=O), 1688 (C=O), 1597, 1462, 1446, 1372, 1260, 1175, 1091, 1019, 812 and 748 cm^{-1}.

HR ESI-MS:$[C_{28}H_{33}NNaO_5S]^+$ = $[M+Na]^+$ requires 518.1972; found 518.1981

TLC: R_f = 0.4 (4:1, Hex/EtOAc).

Ethyl 3-[4-(5-hexylthiophen-2-yl)-5,5-dimethyl-1-p-tolyl-2,5-dihydro-1H-pyrazol-3-yl] propanoate (21)



21

1,4-Keto-ester **16g** (30 mg, 0.09 mmol), and p- Tol-$NHNH_2$ (71 mg, 0.45 mmol), in EtOH (3 mL) were stirred for 3 days at 70 °C. Purification by flash column chromatography (4:1 hexanes:EtOAc) gave the pyrazole derivative **21** (25 mg, 0.055 mmol, 61%) as a pale red oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.78 (2 H, d, *J* = 8.2 Hz), 7.67 (1 H, s), 7.30 (1 H, d, *J* = 8.2 Hz), 6.48 (1 H, d, *J* = 3.7 Hz), 6.18 (1 H, d, *J* = 3.7 Hz), 4.11 (2 H, q, *J* = 7.2 Hz), 2.70 (2 H, t, *J* = 7.6 Hz), 2.53-2.51 (2 H, m), 2.46-2.40 (5 H, m), 2.01 (3 H, s), 1.62-1.56 (7 H, m) and 0.89 (3 H, t, *J* = 6.7 Hz) ppm.

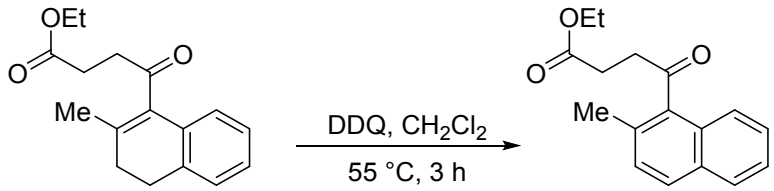
^{13}C NMR (100 MHz, $CDCl_3$): δ = 172.9, 156.8, 146.9, 143.9, 136.2, 135.6, 134.3, 129.6, 128.2, 126.7, 123.9, 60.6, 31.7, 31.6, 30.9, 30.2, 30.0, 29.8, 28.9, 22.9, 22.7, 21.8, 21.7, 14.3 and 14.2 ppm.

IR (neat): 3202, 2956, 2927, 2855, 1734 (OC=O), 1598, 1462, 1374, 1343, 1168, 1092, 1040, 1021, 810 and 706 cm^{-1}.

HR ESI-MS:$[C_{27}H_{38}N_2NaO_2S]^+$ = $[M+Na]^+$ requires 477.2546; found 477.2557

TLC: R_f = 0.4 (4:1, Hex/EtOAc)

Ethyl 4-(2-methylnaphthalen-1-yl)-4-oxobutanoate (22)



10a **22**

1,4-keto-ester **10a** (40 mg, 0.14 mmol) and DDQ (50 mg, 0.22 mmol), in DCM (5 mL) were stirred for 3 h at 55 °C. Purification by flash column chromatography (9:1 hexanes:EtOAc) gave the naphthalene-1,4-keto-ester **22** (36 mg, 0.13 mmol, 90%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.83 (1 H, d, *J* = 7.7 Hz), 7.78 (1 H, d, *J* = 8.3 Hz), 7.68 (1 H, d, *J* = 8.0 Hz), 7.51-7.43 (2 H, m), 7.31 (1 H, d, *J* = 8.5 Hz), 4.23 (2 H, q, *J* = 7.1 Hz), 3.20 (2 H, t, *J* = 6.4 Hz), 2.82 (2 H, t, *J* = 6.4 Hz), 2.43 (3 H, s) and 1.32 (3 H, t, *J* = 7.1 Hz) ppm.

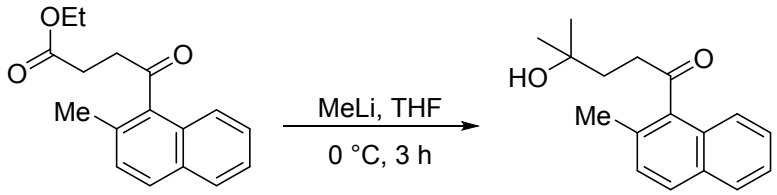
^{13}C NMR (100 MHz, $CDCl_3$): δ = 208.3, 172.8, 138.0, 131.8, 130.5, 129.4, 129.0, 128.6, 128.3, 127.1, 125.6, 124.1, 60.9, 40.2, 27.9, 19.4 and 14.4 ppm.

IR (neat): 3053, 2981, 2924, 2854, 2363, 1733 (OC=O), 1702 (C=O), 1594, 1509, 1458, 1392, 1258, 1206, 1163, 1057 and 815 cm^{-1}.

HR ESI-MS:$[C_{17}H_{18}NaO_3]^+$ = $[M+Na]^+$ requires 293.1148; found 293.1148

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

4-Hydroxy-4-methyl-1-(2-methylnaphthalen-1-yl)pentan-1-one (23)



22 **23**

1,4-keto-ester **22** (60 mg, 0.2 mmol), and MeLi (1.33 mmol, 0.83 ml), in Dry THF (5 mL) were stirred for 3 h at 0 °C. Purification by flash column chromatography (3:1 hexanes:EtOAc) gave naphthalene-keto-tertiary alcohol **23** (50 mg, 0.195 mmol, 89%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.82 (1 H, d, *J* = 7.8 Hz), 7.76 (1 H, d, *J* = 8.3 Hz), 7.58 (1 H, d, *J* = 7.9 Hz), 7.49-7.42 (2 H, m), 7.30 (1 H, d, *J* = 8.4 Hz), 3. 02 (2 H, t, *J* = 7.6 Hz), 2.41 (3 H, s), 2.02 (2 H, t, *J* = 7.6 Hz), 177 (1 H, s) and 1.28 (6 H, s) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 211.4, 138.7, 131.8, 130.2, 129.3, 128.9, 128.6, 128.4, 127.1, 125.6, 124.1, 70.3, 40.8, 36.6, 29.6 and 19.6 ppm.

IR (neat): 3410 (OH), 3049, 2982, 2854, 2355, 1700 (C=O), 1600, 1509, 1459, 1391, 1248, 1200, 1153, 10578 and 819 cm^{-1}.

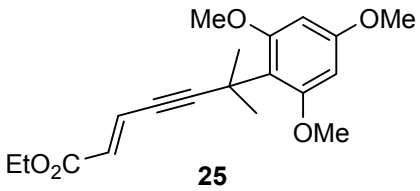
HR ESI-MS:$[C_{17}H_{20}O_2Na]^+$ = $[M+Na]^+$ requires 279.1356; found 269.1349

TLC: R_f = 0.4 (3:1, Hex/EtOAc)

Ethyl (*E*)-6-methyl-6-(2,4,6-trimethoxyphenyl)hept-2-en-4-ynoate (25)

The hydroxyl-ester **24** (60 mg, 0.32 mmol), 1,3,5-trimethoxybenzene (276 mg, 1.64 mmol), in DCM (5 mL), and MsOH (38.4mg, 0.04 mmol, 0.28 ml of 1.4 *M* in DCM) were stirred for 18 h at 0 °C to RT. Purification by flash column chromatography (6:1 hexanes:EtOAc) gave the ester **25** (28 mg, 0.09 mmol, 56%) as a pale yellow oil (based on recovered starting material).

^{1}H NMR (400 MHz, $CDCl_3$): δ = 6.84 (1 H, d, *J* = 15.6 Hz), 6.15 (2 H, s), 6.09 (1 H, d, *J* = 15.9 Hz), 4.19 (2 H, q, *J* = 7.2 Hz), 3.79 (3 H, s), 3.78 (6 H, s), 1.73 (6 H, s) and 1.28 (3 H, t, *J* = 7.2 Hz) ppm



25

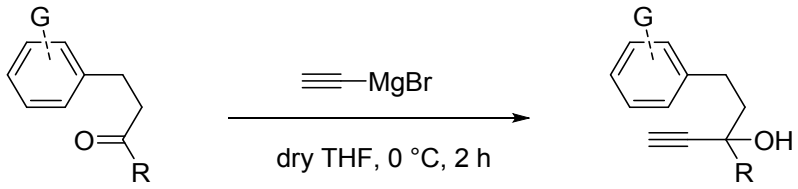
^{13}C NMR (100 MHz, $CDCl_3$): δ = 167.2, 166.7, 159.7, 127.8, 127.6, 114.2, 114.1, 111.6, 92.9, 60.6, 56.2, 55.4, 34.7, 31.0 and 14.4 ppm.

IR (neat): 3388, 2981, 2910, 2333, 2310, 1728 (OC=O), 1672, 1581, 1511, 1374, 1223, 1131, 1042, 1023, 1014 and 769 cm^{-1}.

HR ESI-MS:$[C_{19}H_{24}NaO_5]^+$ = $[M+Na]^+$ requires 355.1516; found 355.1521

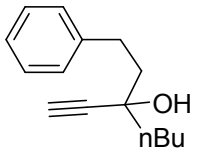
TLC: R_f = 0.4 (6:1, Hex/EtOAc)

Preparation of propargylic alcohols:



3-Phenethylhept-1-yn-3-ol (S_1)

The ketone[8] (160 mg, 0.86 mmol), anhydrous THF (6 mL), ethynyl magnesium bromide (3.4 ml, 1.72 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_1** (178 mg, 0.97 mmol, 96%) as a color less oil



^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31-7.27 (2 H, m), 7.24-7.17 (3 H, m), 2.89-2.85 (2 H, m), 2.51 (1 H, br s), 1.98-1.93 (2 H, m), 1.73-1.68 (2 H, m), 1.55-1.48 (2 H, m), 1.39-1.33 (2 H, m) and 0.93 (3 H, t, *J* = 7.3 Hz) ppm.

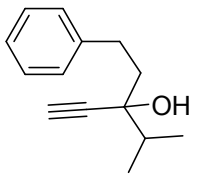
^{13}C NMR (100 MHz, $CDCl_3$): δ = 142.1, 128.6, 126.0, 86.7, 72.9, 71.2, 43.8, 42.1, 30.8, 26.5, 23.0 and 14.2 ppm.

IR (neat): 3450, 3302, 3013, 2858, 2360, 1699, 1600, 1491, 1458, 1068, 1043 and 700 cm^{-1}.

HR ESI-MS:$[C_{15}H_{20}NaO]^+$ = $[M+Na]^+$ requires 239.1406; found 239.1406

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Isopropyl-5-phenylpent-1-yn-3-ol (S_2)



The ketone[9] (220mg, 1.25 mmol), anhydrous THF (7 mL), ethynyl magnesiumbromide (5 ml, 2.5 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_2** (210 mg, 1.04 mmol, 83%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.32-7.27 (2 H, m), 7.25-7.22 (2 H, m), 7.21-7.17 (1 H, m), 2.88 (2 H, t, *J* = 8.6 Hz), 2.51 (1 H, s) 2.05-1.84 (4 H, m), 1.06 (3 H, d, *J* = 6.8 Hz) and 1.03 (3 H, d, *J* = 6.8 Hz) ppm.

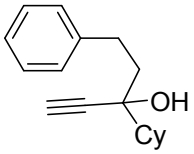
^{13}C NMR (100 MHz, $CDCl_3$): δ = 142.3, 128.6, 128.5, 126.0, 85.5, 74.6, 73.6, 41.2, 37.7, 30.7, 17.9 and 17.0 ppm.

IR (neat): 3450, 3302, 2964, 2929, 2872, 2363, 1648, 1603, 1456, 1042 and 700 cm^{-1}.

HR ESI-MS:$[C_{14}H_{18}NaO]^+ = [M+Na]^+$ requires 225.1250; found 225.1258

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Cyclohexyl-5-phenylpent-1-yn-3-ol (S_3)



The ketone[10] (200 mg, 0.917 mmol), anhydrous THF (5 mL), ethynyl magnesiumbromide (3.6 ml, 1.83 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_3** (150 mg, 0.61mmol, 67%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.30-7.16 (5 H, m), 2.88 (2 H, t, *J* = 8.1 Hz), 2.5 (1 H, s) 2.01-1.88 (4 H, m), 1.81-1.77 (2 H, m), 1.68-1.49 (2 H, m) and 1.29-1.16 (5 H, m) ppm.

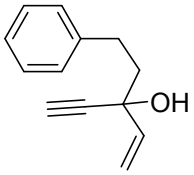
^{13}C NMR (100 MHz, $CDCl_3$): δ = 142.4, 128.6, 128.5, 126.0, 86.1, 74.1, 73.5, 47.5, 41.2, 30.6, 27.8, 26.9, 26.5, 26.4 and 26.3 ppm.

IR (neat): 3450, 3302, 3010, 2854, 2361, 1700, 1603, 1495, 1452, 1061, 1040 and 700 cm^{-1}.

HR ESI-MS:$[C_{17}H_{22}NaO]^+ = [M+Na]^+$ requires 265.1563; found 265.1563

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Phenethylpent-1-en-4-yn-3-ol (S_4)



The ketone[11] (120 mg, 0.75 mmol), anhydrous THF (6 mL), ethynyl magnesium bromide (3 ml, 1.5 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_4** (110 mg, 0.54 mmol, 79%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.29-7.25 (2 H, m), 7.21-7.15 (3 H, m), 5.94 (1 H, dd, *J* = 17.1 & 10.1 Hz), 5.61 (1 H, dd, *J* = 17.1 & 1.1 Hz), 5.22 (1 H, dd, *J* = 10.1 & 1.2 Hz), 2.88-2.74 (2 H, m), 2.64 (1 H, s) and 2.09-1.96 (2 H, m) ppm.

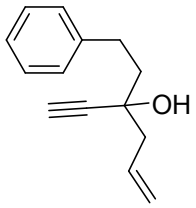
^{13}C NMR (100 MHz, $CDCl_3$): δ = 141.7, 140.7, 128.5, 126.0, 115.3, 84.6, 74.5, 71.5, 44.0 and 30.8 ppm.

IR (neat): 3458, 3298, 3068, 3028, 2936, 2854, 1700, 1608, 1498, 1458, 1090, 920 and 700 cm^{-1}.

HR ESI-MS:$[C_{13}H_{14}NaO]^+$ = $[M+Na]^+$ requires 209.0937; found 209.0941

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Phenethylhex-5-en-1-yn-3-ol (S_5)



The ketone[12] (176 mg, 1 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (4 ml, 2 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_5** (176 mg, 0.88 mmol, 88%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.31-7.27 (2 H, m), 7.24-7.17 (3 H, m), 6.05-5.95 (1 H, m), 5.26-5.19 (2 H, m), 2.91-2.87 (2 H, m), 2.58-2.53 (2 H, m) 2.44-2.38 (1 H, m) and 1.99-1.95 (2 H, m) ppm.

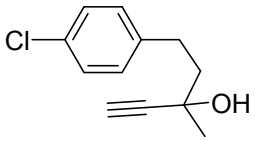
^{13}C NMR (100 MHz, $CDCl_3$): δ = 142.0, 132.9, 128.6, 126.1, 120.1, 86.1, 73.2, 69.9, 46.9, 43.5 and 30.8 ppm.

IR (neat): 3457, 3296, 3064, 3026, 2926, 2864, 1711, 1602, 1495, 1453, 1088, 920 and 699 cm^{-1}.

HR ESI-MS:$[C_{14}H_{16}NaO]^+$ = $[M+Na]^+$ requires 223.1093; found 223.1100

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

5-(4-Chlorophenyl)-3-methylpent-1-yn-3-ol (S_6)



The ketone[13] (150 mg, 0.82 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (3.3 ml, 1.6 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification

by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_6** (160 mg, 0.78 mmol, 95%) as a color less oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.24 (2 H, d, *J* = 8.4 Hz), 7.15 (2 H, d, *J* = 8.4 Hz), 2.85-2.80 (2 H, m), 2.51 (1 H, s), 2.04 (1H, br s), 2.01-1.90 (2 H, m) and 1.55 (3 H, s) ppm.

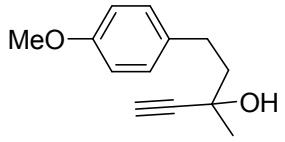
^{13}C NMR (100 MHz, $CDCl_3$): δ = 140.4, 131.8, 129.9, 128.7, 87.3, 72.1, 68.0, 45.1, 30.6 and 30.2 ppm.

IR (neat): 3387, 3298, 2980, 2932, 2865, 1491, 1454, 1371, 1158, 1093, 1016, 907 and 661 cm^{-1}.

HR ESI-MS:$[C_{12}H_{13}ClNaO]^+ = [M+Na]^+$ requires 231.0547; found 231.0547

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

5-(4-Methoxyphenyl)-3-methylpent-1-yn-3-ol (S_7)



The ketone[14] (140 mg, 0.78 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (3.2 ml, 1.6 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_7** (130 mg, 0.64 mmol, 82%) as a pale yellow oil

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.16-7.12 (2 H, m), 6.86-6.82 (2 H, m), 3.79 (3H, s), 2.87-2.74 (2 H, m), 2.51 (1 H, s), 2.12 (1 H, br s), 2.02-1.92 (2 H, m) and 1.55 (3 H, s) ppm

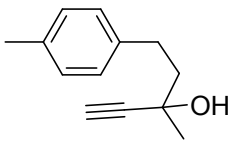
^{13}C NMR (100 MHz, $CDCl_3$): δ = 158.0, 133.9, 129.4, 114.1, 87.5, 71.9, 68.1, 58.4, 45.5, 30.3 and 30.1 ppm.

IR (neat):3423, 3290, 2980, 2933, 2861, 1611, 1584, 1512, 1458, 1244, 1178, 1033, 906 and 649 cm^{-1}.

HR ESI-MS:$[C_{13}H_{16}NaO_2]^+ = [M+Na]^+$ requires 227.1043; found 227.1047

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Methyl-5-p-tolylpent-1-yn-3-ol (S_8)



The ketone[13] (170 mg, 1.04 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (4.2 ml, 2.1 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_8** (165 mg, 0.88 mmol, 84%) as a color less oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15-7.11 (4 H, m), 2.92-2.77 (2 H, m), 2.53 (1 H, s), 2.34 (3 H, s), 2.16 (1 H, br s), 2.01-1.96 (2 H, m) and 1.57 (3 H, s) ppm.

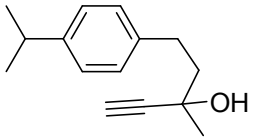
^{13}C NMR (100 MHz, $CDCl_3$): δ = 138.8, 135.5, 129.3, 128.4, 87.5, 71.9, 68.1, 45.4, 30.7 and 21.1 ppm.

IR (neat):3416, 3296, 2979, 2925, 2863, 2363, 1514, 1454, 1372, 1111, 1086, 906 and 810 cm^{-1}.

HR ESI-MS:$[C_{13}H_{16}NaO]^+ = [M+Na]^+$ requires 211.1093; found 211.1097

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

5-(4-Isopropylphenyl)-3-methylpent-1-yn-3-ol (S_9)



The ketone[15] (230 mg, 1.2 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (4.8 ml, 2.4 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_9** (215 mg, 1 mmol, 83%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.15 (4 H, s), 3.01-2.78 (3 H, m), 2.50 (1 H, s), 2.09-1.88 (3 H, m), 1.54 (3 H, s) and 1.23 (6 H, d, *J* = 6.9 Hz) ppm.

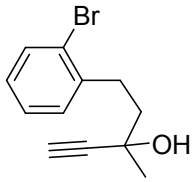
^{13}C NMR (100 MHz, $CDCl_3$): δ = 146.6, 139.1, 128.4, 126.6, 87.5, 71.9, 68.1, 45.3, 33.8, 30.7, 30.1 and 24.2 ppm.

IR (neat): 3398, 3303, 2959, 2931, 2869, 1513, 1459, 1368, 1085, 906, 843 and 820 cm^{-1}.

HR ESI-MS:$[C_{15}H_{20}NaO]^+ = [M+Na]^+$ requires 239.1406; found 239.1411

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

5-(2Bromophenyl)-3-methylpent-1-yn-3-ol (S_{10})



The ketone[16] (135 mg, 0.6 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (2.4 ml, 1.2 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{10}** (130 mg, 0.52 mmol, 87%) as a pale yellow oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.53 (1 H, dd, *J* = 8.0 & 3.2 Hz), 7.27-7.21 (2 H, m), 7.08-7.4 (1 H, m), 3.01-2.96 (2 H, m), 2.52 (1 H, s), 2.11 (1H, br s), 2.01-1.95 (2 H, m) and 1.58 (3 H, m) ppm.

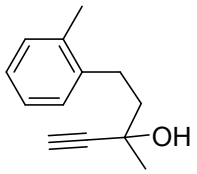
^{13}C NMR (100 MHz, $CDCl_3$): δ = 1401.2, 133.1, 130.5, 127.9, 127.7, 124.6, 87.3, 72.0, 68.1, 43.5, 31.7 and 30.0 ppm.

IR (neat): 3562, 3390, 3296, 3061, 2979, 2932, 2867, 1568, 1469, 1443, 1024 and 753 cm^{-1}.

HR ESI-MS:$[C_{12}H_{13}BrNaO]^+$ = $[M+Na]^+$ requires 275.0042; found 275.0047

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Methyl-5-o-tolylpent-1-yn-3-ol (S_{11})



The ketone[17] (230 mg, 1.42 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (5.6 ml, 2.8 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{11}** (213 mg, 1.13 mmol, 78%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.17-7.10 (4 H, m), 2.89-2.80 (2 H, m), 2.51 (1 H, s), 2.34 (3 H, s), 1.97-1.84 (2 H, m) and 1.56 (3 H, s) ppm.

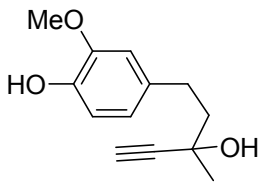
^{13}C NMR (100 MHz, $CDCl_3$): δ = 139.9, 136.1, 130.4, 128.9, 126.2, 97.4, 71.9, 68.1, 44.1, 29.9, 28.6 and 19.3 ppm.

IR (neat): 3397, 3297, 3017, 2978, 2932, 1491, 1459, 1374, 1158, 1116, 1081, 1024, 905 and 743 cm^{-1}.

HR ESI-MS:$[C_{13}H_{16}NaO]^+$ = $[M+Na]^+$ requires 211.1093; found 211.1098

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

4-(3-Hydroxy-3-methylpent-4-ynyl)-2-methoxyphenol (S_{12})



The ketone[18] (100 mg, 0.5 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (2.1 ml, 1.03 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (4:1 hexane:EtOAc) gave alcohol **S_{12}** (85 mg, 0.39 mmol, 84%) as a colorless oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 6.84-6.82 (1 H, m), 6.72-6.66 (2 H, m), 5.52 (1 H, br s), 3.88 (3 H, s), 2.84-2.74 (2 H, m), 2.51 (1 H, s), 2.13 (1 H, br s), 2.01-1.91 (2 H, m) and 1.55 (3 H, s) ppm.

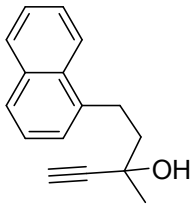
^{13}C NMR (125 MHz, $CDCl_3$): δ = 146.6, 143.9, 133.7, 121.1, 114.5, 111.2, 87.5, 71.9, 68.1, 56.0, 54.5, 30.9 and 30.2 ppm.

IR (neat):3410, 3287, 2926, 2853, 2361, 1605, 1516, 1462, 1369, 1268, 1153, 1120, 1090, 1032 and 798 cm^{-1}.

HR ESI-MS:$[C_{13}H_{16}NaO_3]^+$ = $[M+Na]^+$ requires 243.0992; found 243.0999

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Methyl-5-(naphthalen-1-yl)pent-1-yn-3-ol (S_{13})



The ketone[9] (198 mg, 1 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (4 ml, 2 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{13}** (205 mg, 0.91mmol, 91%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.13 (1 H, d, *J* = 7.6 Hz), 7.87 (1 H, d, *J* = 7.2 Hz), 7.74 (1 H, d, *J* = 7.5 Hz), 7.56-7.47 (2 H, m), 7.44-7.38 (2 H, m), 3.39-3.32 (2 H, m), 2.62 (1H, s), 2.18-2.08 (2 H, m) and 1.63 (3 H, s) ppm.

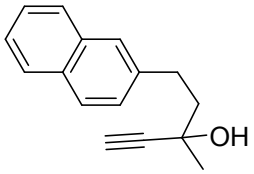
^{13}C NMR (100 MHz, $CDCl_3$): δ = 138.0, 134.1, 131.9, 128.9, 126.9, 126.1, 126.0, 125.8, 125.7, 123.8, 87.5, 72.1, 68.2, 44.5, 30.2 and 28.4 ppm.

IR (neat): 3419, 3292, 3052, 2978, 2939, 2355, 1507, 1455, 1385, 1369, 1158, 1105, 905 and 784 cm^{-1}.

HR ESI-MS:$[C_{16}H_{16}NaO]^+ = [M+Na]^+$ requires 247.1093; found 247.1101

TLC: $R_f = 0.4$ (5:1, Hex/EtOAc)

3-Methyl-5-(naphthalen-2-yl)pent-1-yn-3-ol (S_{14})



The ketone [9] (198 mg, 1 mmol), anhydrous THF (7 mL), ethynyl magnesium bromide (4 ml, 2 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{14}** (200 mg, 0.89 mmol, 90%) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.83-7.77 (3 H, m), 7.68 (1 H, s), 7.48-7.37 (3 H, m), 3.10-2.98 (2 H, m), 2.55 (1H, s), 2.12-2.06 (2 H, m) and 1.60 (3 H, s) ppm

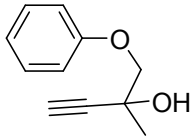
^{13}C NMR (100 MHz, $CDCl_3$): δ = 139.4, 133.8, 132.2, 128.2, 127.8, 127.5, 127.4, 126.5, 126.1, 125.4, 87.5, 72.1, 68.2, 45.2, 31.4 and 30.2 ppm.

IR (neat): 3420, 3297, 3055, 2968, 2929, 2358, 1506, 1457, 1386, 1366, 1157, 1107, 905 and 769 cm^{-1}.

HR ESI-MS:$[C_{16}H_{16}NaO]^+ = [M+Na]^+$ requires 247.1093; found 247.1091

TLC: $R_f = 0.4$ (5:1, Hex/EtOAc)

2-Methyl-1-phenoxybut-3-yn-2-ol (S_{15})



The ketone[19] (80 mg, 0.54 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (2.2 ml, 1.08 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{15}** (70 mg, 0.4 mmol, 75%) as a color less oil.

^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.32-7.29 (2 H, m), 7.01-6.95 (3 H, m), 4.05 (1 H, d, J = 8.9 Hz), 3.94 (1 H, d, J = 8.9 Hz), 2.93 (1 H, br s), 2.49 (1 H, s) and 1.62 (3 H, s) ppm

^{13}C NMR (125 MHz, $CDCl_3$): δ = 158.6, 129.7, 121.6, 115.0, 85.5, 75.3, 72.2, 67.1 and 26.0 ppm.

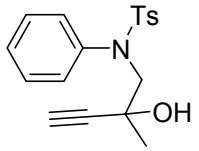
IR (neat): 3480, 3287, 2926, 2855, 2363, 2338, 1653, 1624, 1491, 1454, 1077, 839 and 731 cm^{-1}.

HR ESI-MS:$[C_{11}H_{12}NaO_2]^+$ = $[M+Na]^+$ requires 199.0730; found 199.0730

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

N-(2-Hydroxy-2-methylbut-3-ynyl)-4-methyl-N-phenylbenzenesulfonamide (S_{16})

The ketone[20] (200 mg, 0.66 mmol), anhydrous THF (5 mL), ethynyl magnesium bromide (2.6 ml, 1.32 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (5:1 hexane:EtOAc) gave alcohol **S_{16}** (160 mg, 0.49 mmol, 74%) as a red color oil.



^{1}H NMR (500 MHz, $CDCl_3$): δ = 7.43 (2 H, d, *J* = 8.2 Hz), 7.29-7.27 (3 H, m), 7.24 (2 H, d, *J* = 8.2 Hz), 7.11-7.09 (2 H, m), 3.78 (2 H, s), 2.42 (3 H, s), 2.29 (1 H, s) and 1.48 (3 H, s) ppm.

^{13}C NMR (125 MHz, $CDCl_3$): δ = 144.1, 141.2, 134.6, 129.6, 129.4, 129.0, 128.2, 128.0, 85.7, 73.0, 67.8, 61.1, 27.5 and 21.7 ppm.

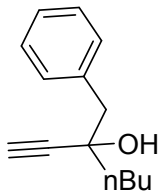
IR (neat): 3482, 3288, 2936, 2858, 2368, 2332, 1655, 1628, 1492, 1451, 1071, 837 and 730 cm^{-1}.

HR ESI-MS:$[C_{18}H_{19}NNaO_3S]^+$ = $[M+Na]^+$ requires 352.0978; found 352.0985

TLC: R_f = 0.4 (5:1, Hex/EtOAc)

3-Benzylhept-1-yn-3-ol (S_{17})

The ketone[8] (176 mg, 1 mmol), anhydrous THF (6 mL), ethynyl magnesium bromide (4 ml, 2 mmol, 0.5 M in THF) were stirred for 2 h at 0 °C. Purification by flash column chromatography (9:1 hexane:EtOAc) gave alcohol **S_{17}** (170 mg, 0.84 mmol, 84%) as a color less oil.



S_{17}

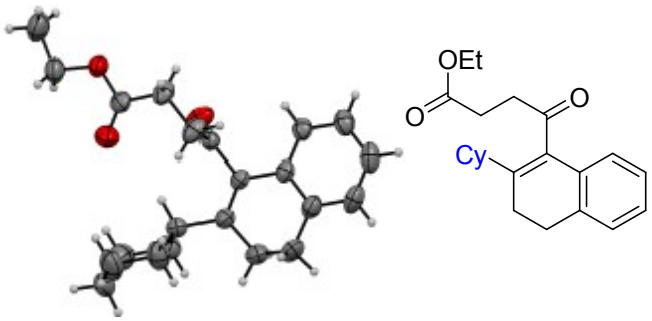
^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.34-7.25 (5 H, m), 3.01 (1 H, d, J = 13.6 Hz), 2.89 (1 H, d, J = 13.6 Hz), 2.46 (1 H, s), 1.73-1.69 (2 H, m), 1.64-1.53 (2 H, m), 1.43-1.32 (2 H, m) and 0.93 (3 H, t, *J* = 7.3 Hz) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 136.0, 131.0, 128.3, 127.2, 86.4, 73.8, 71.0, 48.1, 26.6, 23.0 and 14.2 ppm.

IR (neat): 3450, 3302, 3013, 2858, 2360, 1699, 1600, 1491, 1458, 1068, 1043 and 700 cm^{-1}.

HR ESI-MS:$[14_3H_{18}NaO]^+$ = $[M+Na]^+$ requires 225.1250; found 225.1254

TLC: R_f = 0.4 (9:1, Hex/EtOAc)

Crystallographic Data and Structure Refinements Summary for Compound **10f**	
Molecular Structure (ORTEP Diagram)	
CCDC number	CCDC 1451186
Formula	$C_{22}H_{28}O_3$
Formula weight	340.44
Color	light yellow
Crystal morphology	Hexagonal
Temperature/K	296(2)
Wave length/Å	0.71073
Crystal system	Triclinic
Space group	P-1
a (Å)	7.8366(4)
b (Å)	8.8547(4)
c (Å)	14.3134(8)
α (°)	84.725(2)
β (°)	88.103(2)
γ (°)	87.621(2)

Volume (Å3)	987.73(8)
Z	2
Density (g/ml)	1.145
μ (1/mm)	0.075
F (000)	368
θ (min, max)	0.9890-0.9820
No. of unique reflections	12477
No. of parameters	227
R_obs, wR2_obs	0.0581,0.1159
Δρmin, Δρmax (eÅ-3)	-0.136,0.169
Goodness-of-fit on F^2	1.051

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